PB81-124901

Summary of Audit Performance: Measurement of SO2, NO2, Sulfate, Nitrate, Lead, Hi-Vol Flow Rate, 1978

(U.S.) Environmental Monitoring Systems Lab.
Research Triangle Park, NC

Jun 80

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711

EPA-600/4-80-017
June 1980

PB81-124901

Research and Development

EPA

Summary of Audit Performance

Measurement of SO_2, NO_2, Sulfate, Nitrate, Lead, Hi-Vol Flow Rate—1978

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TECHNICAL REPORT DATA

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1. REPORT NO. EPA 600/4-80-017	2.	3. RECIPIENT'S ACCESSION NO. PB81 124901
4. TITLE AND SUBTITLE SUMMARY OF AUDIT PERFORMANCE: MEASUREMENT OF SO_2, NO_2, SULFATE, NITRATE, LEAD, HI-VOL FLOW RATE - 1978		5. REPORT DATE June 1980
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Steven M. Bromberg, Robert L. Lampe, Berne I. Bennett		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Environmental Monitoring Systems Laboratory Quality Assurance Division Research Triangle Park, NC 27711		10. PROGRAM ELEMENT NO. A09A1D
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Monitoring Systems Laboratory Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE EPA 600/08

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The report summarizes the results of the quality assurance audits for the period from January, 1978 through December, 1978. Pollutants for which audits were conducted and results reported are SO_2, NO_2, sulfate, nitrate, lead, and hi-vol flow rate. The operation of the EPA audit program is also described.

5

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution	Ambient air	68 A
Quality control	Criteria pollutants	43 F

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

SUMMARY OF AUDIT PERFORMANCE: MEASUREMENT OF SO_2, NO_2, CO, SULFATE, NITRATE, LEAD, AND HI-VOL FLOW RATE

1978

by

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FOREWORD

Measurement and monitoring research efforts are designed to anticipate potential environmental problems, to support regulatory actions by developing an in-depth understanding of the nature and processes that impact health and the ecology, to provide innovative means of monitoring compliance with regulations, and to evaluate the effectiveness of health and environmental protection efforts through the monitoring of long-term trends. The Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina, has responsibility for: assessment of environmental monitoring technology and systems; implementation of agency-wide quality assurance programs for air pollution measurement systems; and supplying technical support to other groups in the Agency including the Office of Air, Noise and Radiation, the Office of Toxic Substances and the Office of Enforcement.

The following investigation was conducted as part of the routine Environmental Protection Agency quality assurance program. Results of quality control audits sponsored by the Environmental Monitoring Systems Laboratory for calendar year 1978 are presented. Measurement methods for SO_2, NO_2, CO, Pb, $SO_4^=$, NO_3^-, and hi-vol flow rate were audited. Preceding reports in this series have dealt with similar topics for 1976 and 1977.

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ABSTRACT

The Quality Assurance Division of the Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina conducts an ambient air audit program. Measurement principles for sulfur dioxide, nitrogen dioxide, carbon monoxide, sulfate-nitrate, and lead are audited on a semiannual basis. Blind samples, the concentrations of which are known only to the EPA, are sent to the participating laboratories. Hi-vol sampler flow rate audits are conducted annually using a modified orifice. The analytical results are returned to the Quality Assurance Division for evaluation. After processing, an individual report is returned to each participant.

This report contains a summary of audit results obtained during calendar year 1978.

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ACKNOWLEDGEMENTS

The authors would like to thank all the participants for their cooperation during the past year. Also due a word of thanks are the programmers of the Statistical and Technical Analysis Branch, EMSL, Research Triangle Park, North Carolina, for developing the data management systems necessary to store and summarize the audit data; the EPA Regional Quality Control Coordinators; and the technical reviewers for reviewing a very tedious document.

SECTION 1

INTRODUCTION

Since 1972 the Environmental Protection Agency (EPA) has been engaged in a performance audit program of various monitoring groups throughout the United States and in several foreign countries. The audit program is only one part of an overall quality assurance program, therefore, the results should not be construed as an absolute indicator of data quality. Used along with information obtained from an internal quality control program, however, the conclusions can be quite meaningful.

The purposes of the audit program are twofold. The first, from a participant standpoint, is most important. Agencies are furnished a means of rapid self-evaluation of the specific operation under study. The second objective of the program is to provide EPA with a continuing index of the validity of data reported to air quality data banks.

The program is being coordinated through the 10 EPA Regional Offices (RO) by the Quality Assurance Division (QAD) of the Environmental Monitoring Systems Laboratory (EMSL), Environmental Research Center, Research Triangle Park, North Carolina 27711. Comments, questions, or applications to participate in the program should be sent to the above address.

This publication is the third of a continuing series of yearly summary reports. The document covers the period from January through December, 1978.

Users of the information contained in this report should take note of some limitations imposed in gathering the data. With the exception of the carbon monoxide (CO) audit, the surveys checked only a portion of the entire system. The sulfur dioxide (SO_2), nitrogen dioxide (NO_2), sulfate-nitrate ($SO_4^=$-NO_3^-), and lead (Pb) surveys examined only the analytical portion of the system. The Hi-vol audit checked only the flow rate portion of the method. No restrictions were placed on the methodology used by the participants (however, the method used had to be compatible with the audit samples). To the extent possible, the various methods employed were documented.

The following sections include discussions of the program operation, descriptions of the audit materials, the statistical approach used to analyze the data, and the results. The Results Section includes data for calendar year, 1978. The appendix contains the raw data from the audit sample analysis.

SECTION 2

PROGRAM COORDINATION

Participants in the audits were selected by the Regional Quality Control Coordinator in each of the 10 Regions. Once a potential participant has received audit samples for a particular pollutant, he is automatically notified of subsequent surveys for that pollutant. Participants are assigned an identification number which remains with the agency throughout all audits for all pollutants.

After the audit roster is completed for a particular survey, instructional materials and unknown samples are mailed. The participants are allowed 5 to 6 weeks in which to return their results. After these results are entered into a data bank, individual reports are returned to the participants. This report indicates the acceptable ranges for each sample as well as the value reported by the agency. Figure 1 is an example of an individual report for $SO_4^=$.

In order to determine whether incorrect results are due to inherent problems with a laboratory procedure or to just a "single event", recheck samples are sent to laboratories whose results do not meet certain criteria. Thus, by having a second chance to analyze a set of samples, real deficiencies can be distinguished from one-time problems.

INTER-LABORATORY STUDY RESULTS

(AUGUST 1977)

POLLUTANT - SO4

123456
Mr. J. Doe
5432 Anywhere St.
Yourtown, USA

UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER	REPORTED VALUE	SAMPLE RANGE		TARGET RANGE	
3143	.180	.000	.000	.000	.000
4111	9.900	10.545	11.655	9.435	12.765
5251	11.840	12.825	14.175	11.475	15.525
6116	14.090	15.390	17.010	13.770	18.630
7122	2.750	2.850	3.150	2.550	3.450
8112	1.760	1.995	2.205	1.785	2.415

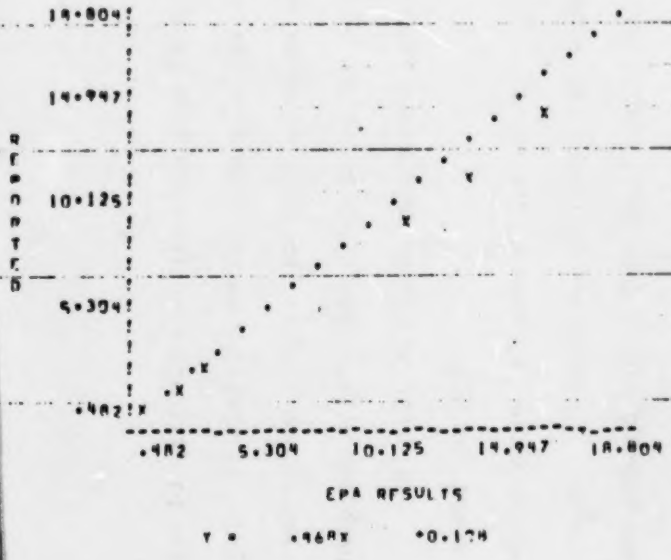

Figure 1. Example of Individual Report.

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SECTION 3

STATISTICAL APPROACH

A primary concern at the onset of the program was the establishment of acceptance criteria to enable individual participants to judge their performance. Initially, there was little guidance, and the choices of acceptable limits were somewhat arbitrary. As more data was gathered through the audit program, subsequent and more realistic acceptance limits were set.

For convenience, two acceptable ranges were defined. The "Sample range" contains the variability attributable to sample material. This estimation was based on the repeated analysis of several samples from each concentration range by one laboratory. Using the precision of the set of samples under consideration plus past data from similar samples, the Sample ranges were chosen. These ranges should be the goal of each agency; it is unreasonable to expect all laboratories to fall within these ranges on any given analysis. However, falling within these values repeatedly indicates a facility with excellent precision and accuracy. Falling outside the Sample ranges does not necessarily indicate problems.

The "Target range" has been constructed to include sample variability and interlaboratory variability. A laboratory falling outside the Sample range but within the Target range should feel comfortable with its results. However, if their results fall outside the Target range, the accuracy of the analysis should be considered suspect. The Target range is based on the past performance of all participants. The percent difference between reported results and the true value (determined by QAD) was established for past surveys. Applying this percent difference to all samples over all surveys, an average difference was determined which was used to calculate the Target ranges.

When evaluating results based on the acceptable ranges, one must consider the usage of the data. For some purposes the Sample range may be too wide; for others the Target range may be too narrow. Thus, judgment should be exercised whenever comparing ranges with results.

A preferable method of evaluating performance "after the fact" is to compare individual results with the tables entitled "Absolute Percent Difference" (See Results Section). These tables are frequency distribution tables of the percent difference between EPA and reported values. The relationship of individual performance to overall study performance can be determined using these tables.

Beginning with calendar year 1979, the use of Sample and Target ranges will end. Replacing these QAD estimates of performance will be frequency distribution tables based on past performances. This new reporting format will allow each monitoring group to judge not only their accuracy, but also their relative performance to other groups doing similar analyses.

Two outlier tests were used as part of the overall analysis and to screen data for further analysis. The first test was employed to screen results that were grossly in error. To be eliminated from further analyses, a laboratory had to report all samples outside the Target ranges for the respective pollutants. These data appear only in the Appendix and are marked with an asterisk (*). No further statistical analyses in this report contain these data. Data appearing in table columns labeled "All data", or containing no specific designation, are results subjected to the first test.

A second outlier test, using Chauvenet's technique (1) was also used. Depending upon the number of results for each concentration, a factor ranging from 2.1 for 20 samples to 3.3 for 300 samples, was chosen. This factor was multiplied by the standard deviation of the sample as determined from the participant results. Results outside the range determined by the expression ([factor] x [standard deviation]) ± study mean were identified as outliers. These data are identified in the "Outliers removed" columns of selected tables.

Several summaries have been used to condense the large amounts of data into a more manageable form. Tables in the Appendix are sequential listings of all data by sample concentration for each audit. Statistical summaries of the sequentially listed data are also presented.

SECTION 4

AUDIT MATERIALS

AMBIENT SULFUR DIOXIDE SAMPLES

The commercially produced sample material consisted of freeze-dried mixtures of sodium sulfite and potassium tetrachloromercurate (TCM) contained in 5 ml sealed glass ampoules. Sample sets were comprised of 5 ampoules containing approximately 3 to 61 μg of SO_2 equivalent per container. The samples were immediately placed in freezers upon receipt with the expectation that low temperatures would preserve the integrity of the material. Initial EPA analyses were performed immediately after receipt. Reanalyses after several months demonstrated that freezing did not completely stabilize the sulfite content as indicated by the continued decline in SO_2 levels. Subsequent analyses of the samples have shown that, while the decay is not completely eliminated, the rate has been substantially reduced. Analyses were performed by the reference method for the determination of SO_2 in the atmosphere (pararosaniline method)(2). The sample, when dissolved in 0.04 N TCM forms a dichlorosulfitomercurate complex. This complex is reacted with pararosaniline and formaldehyde to form intensely colored pararosaniline sulfonic acid. The absorbance of the solution is measured spectrophotometrically at 548 nm.

Ten samples from each concentration were analyzed (Table 1) and are used in determining the acceptable ranges reported to participants. The tabulated values are based on the assumption that individual samples were collected in 50 ml of absorbing reagent with a total sample air volume of 300ℓ.

AMBIENT NITROGEN DIOXIDE SAMPLES

The commercially produced samples consisted of 4 ml of aqueous sodium nitrite ($NaNO_2$) in 5 ml glass vials with inert screw-cap closures. A set consisted of five vials. When mixed with absorbing reagents, the samples simulated ambient samples ranging from 0.12 to 0.93 μg/ml.

EPA analysis of 10 samples from each concentration was performed using an equivalent method for the determination of NO_2 in ambient air (3). Measurements were made on a Varian Model 635 UV-Vis spectrophotometer at 540 nm. Aqueous calibration standards were prepared to encompass a linear range from 0 to 1.6 μg/ml of NO_2 (Table 2). The values contained in Table 2 are utilized in determining the acceptable ranges reported to participants. Values are based on the assumption that the sample was collected in 50 ml of absorbing reagent.

AMBIENT CARBON MONOXIDE SAMPLES

Samples consisted of commercially produced mixtures of CO and artificial air. Mixtures also contained methane (CH_4) and 350 ppm of carbon dioxide (CO_2). Specially treated aluminum cylinders were utilized to improve gas stability. Sample concentrations ranged from approximately 4 to 42 ppm of CO. Each participant received a set of 3 cylinders, one from each concentration level.

Analysis by EPA of cylinders from each concentration was performed using a Bendix Model 8501 NDIR analyzer. National Bureau of Standards, Standard Reference material (SRM) gases were used as reference standards. Three SRM's

TABLE 1. MEAN AND STANDARD DEVIATION OF SO_2 ACCEPTANCE ANALYSIS ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
SO_2 audit $_{0478}$	21.70	0.70	64.41	1.10	64.72	1.10	126.20	1.70	204.00	3.20
SO_2 audit $_{1078}$	9.07	1.17	38.80	2.27	88.90	3.77	128.30	3.70	192.20	3.17

TABLE 2. MEAN AND STANDARD DEVIATION OF NO_2 ACCEPTANCE ANALYSIS ($\mu g/ml$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
NO_2 audit 0678	0.12	0.004	0.24	0.004	0.24	0.003	0.37	0.004	0.69	0.004
NO_2 audit 1278	0.26	0.007	0.39	0.004	0.52	0.004	0.70	0.005	0.93	0.008

at nominal concentrations of 9, 46, and 95 ppm CO were used as the primary reference gases.

Ten samples from each concentration were analyzed. Table 3 lists the results of these analyses. These values were later used in determining the acceptable ranges reported to participants.

SULFATE-NITRATE SAMPLES

The commercially prepared samples consisted of 19 mm by 20 cm (0.75 x 8 in) fiberglass filter strips with depositions of potassium sulfate (K_2SO_4) and lead nitrate ($Pb[NO_3]_2$). Filter strip sample sets were comprised of combinations of differing SO_4 and NO_3 concentrations. Each strip was packaged in a plastic envelope. The concentration of sulfate ranged from 0 (blank) to 40 $\mu g/m^3$. Nitrate concentrations ranged from 0 (blank) to 14 $\mu g/m^3$. Concentrations were calculated assuming that samples were collected on a 20 by 25.4 cm (8 x 10 in) filter with a total air volume of 2000 m^3.

It was felt that gravimetric preparation of the solution deposited onto the filter strips was more accurate than an analysis using existing procedures. Thus, the values accepted as "true values" are the vendor certifications. Verification analyses ensured that the accuracy and precision of the samples were acceptable. Table 4 lists the concentrations of samples used during the audit.

LEAD SAMPLES

The commercially prepared samples consisted of 19 mm by 20 cm (0.75 x 8 in) fiberglass filter strips with depositions of lead nitrate ($Pb[NO_3]_2$). Filter strip sample sets were comprised of combinations of differing lead concentrations; each packaged in a plastic envelope. The concentrations of

TABLE 3. MEAN AND STANDARD DEVIATION OF CO ACCEPTANCE ANALYSIS (PPM)

	Conc. 1		Conc. 2		Conc. 3	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
CO audit - 0378	7.15	0.10	20.23	0.09	42.08	0.08
CO audit - 0978	3.82	0.05	14.56	0.18	36.45	0.07

TABLE 4. SULFATE AND NITRATE SAMPLE VALUES ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3	SO_4	NO_3
SO_4-NO_3 audit 0278	0.00	0.00	1.80	0.45	2.70	1.44	9.60	10.50	12.00	12.00	14.40	14.40
SO_4-NO_3 audit 0878	1.30	0.72	3.00	1.80	11.10	4.80	13.50	6.00	26.40	9.60	39.60	11.40

lead ranged from 0 (blank) to approximately 13 $\mu g/m^3$. Concentrations were calculated assuming the samples were collected on a 20 by 25.4 cm (8 x 10 in) filter with a total air volume of 2000 m^3.

Gravimetric preparation of the solution deposited onto the filter strips was assumed more accurate than analysis using existing procedures. Thus, "true values" were the vendor certifications. Verification analyses ensured that the accuracy and precision of the samples were acceptable. Table 5 lists the concentrations of the samples used during the audit.

TABLE 5. LEAD SAMPLE VALUES ($\mu g/m^3$)

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Pb audit 0178	0.00	0.60	2.04	6.60	10.20	12.60
Pb audit 0678	0.00	0.42	1.50	4.95	9.90	12.00

HI-VOL REFERENCE FLOW DEVICE (ReF)

A single ReF was supplied to each participating agency. Organizations were instructed to check as many Hi-vol sampling units as feasible within the allotted time. The auditing unit received by each laboratory consisted of a modified orifice (ReF), wind deflector, manometer, and resistance plates (to change flow rates).

During auditing of the flow rate of a Hi-vol sampler, the ReF was mounted on top of the sampler replacing the filter face plate (Figure 2). A wind deflector was necessary to prevent fluctuation in the readings due to wind flow across the orifice. The resistance plates, when inserted into the ReF, simulated various filter loading conditions (Figure 3).

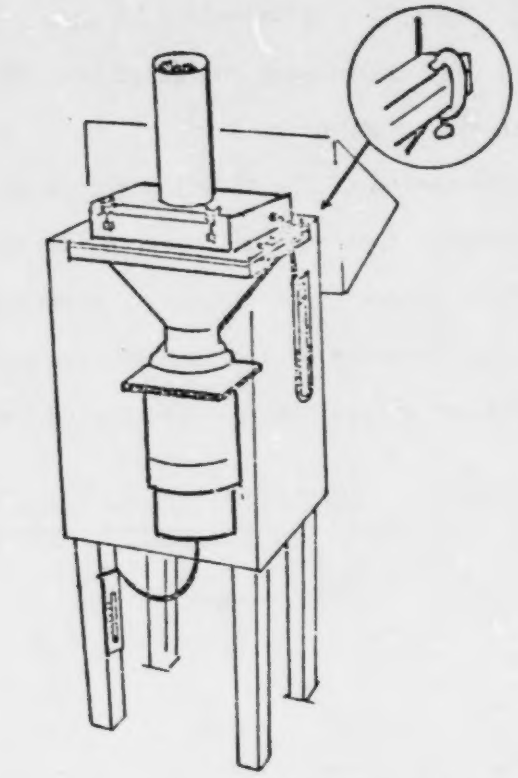

Figure 2. ReF mounted on hi-vol sampler.

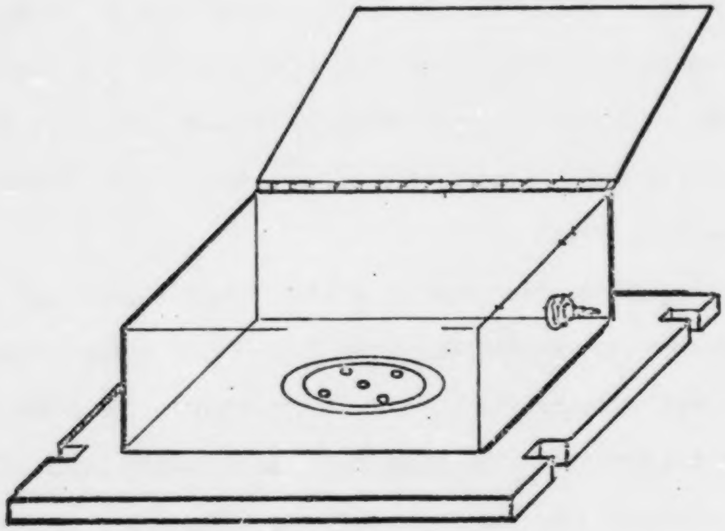

Figure 3. ReF with resistance plate.

By calibrating each ReF with a positive displacement meter (Roots meter), in conjunction with measurements of pressure drops and temperatures, an individual calibration curve in the form of an orifice equation was derived. The equation shown below was used to determine the "K" orifice constant for each unit.

$$Q_1 = AYC \sqrt{\frac{\Delta P\ T_1}{P_1}} \qquad (1)$$

where Q_1 = volumetric flow at conditions of T_1 and P_1 (m^3/min)

A = area of orifice (in^2)

Y = expansion factor

C = orifice coefficient

ΔP = pressure drop across orifice (in H_2O)

P_1 = upstream pressure (barometric pressure, mm Hg)

T_1 = upstream temperature (ambient temperature, °K)

Because A is constant for a given orifice, and Y and C are essentially constant over the flow range in question, a new orifice constant "K" was defined as:

$$K = AYC \qquad (2)$$

Thus, the orifice equation becomes:

$$Q_1 = K \sqrt{\frac{\Delta P\ T_1}{P_1}} \qquad (3)$$

During calibration of the ReF, Q_1, ΔP, T_1, and P_1 were also measured. The constant K was determined by regressing a series of Q_1 measurements onto the square root of the values under the radical.

During an audit, field personnel measured ΔP, T_1, and P_1. By knowing K, the "true flow" can be calculated. This flow was compared with the flow rate measured by the Hi-vol sensor to determine the accuracy of flow measurements.

SECTION 5

RESULTS

AMBIENT SULFUR DIOXIDE

Participant Characteristics

Sulfur dioxide study number 0478 began in April, 1978. Out of 178 sample sets requested by participants, 125 sets of data were returned for a response rate of 70 percent. Study number 1078 began in October, 1978. Out of 131 sample sets requested, 100 sets of data were returned for a response rate of 76 percent. The total number of laboratories discontinuing SO_2 wet chemical analysis in favor of continuous monitors continues to increase. This is supported by the steady decrease in participants.

Table 6 indicates the monitoring agency distribution.

TABLE 6. SO_2 AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
SO_2 audit - 0478						
Agencies requesting samples	3	6	62	74	33	178
Agencies returning data	1	3	51	51	19	125
SO_2 audit - 1078						
Agencies requesting samples	1	1	49	56	24	131
Agencies returning data	1	0	37	49	14	100

Procedures for analyses were grouped into three broad categories: manual pararosaniline, automated pararosaniline, and other. Table 7 lists the analytical methods employed and the number of respondents using a particular method.

TABLE 7. SO_2 ANALYTICAL METHODS

Method	Agencies using method Audit 0478	 Audit 1078
Manual pararosaniline	93	79
Automated pararosaniline	29	21
Other	3	0

It should be noted that laboratories tend to define the procedure used in very general terms. Thus, an agency using the manual pararosaniline technique may not have used the method exactly as it appeared in 40 CFR 50.11 (2).

Acceptable Ranges

As previously described, two ranges were used as one means of judging performance. The Sample and Target ranges for the studies are listed in Table 8 and apply to sample values in increasing concentrations.

Sample Ranges were not determined by a method described earlier in our series (4) and were arbitrarily set at one half the Target ranges. It was determined from earlier studies that the average percent difference between the reported results and EPA determined values was ±20 percent. Thus, this value has been used for all Target ranges.

TABLE 8. SO_2 SAMPLE AND TARGET RANGES (%)

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5
Sample range	±10	±10	±10	±10	±10
Target range	±20	±20	±20	±20	±20

Using those criteria, a tabulation was made of the number of agencies reporting results within the ranges. For audit 0478, 48 (38%) of the agencies reported all 5 results within the Target ranges, while 12 (10%) of the laboratories reported all results outside these ranges. The corresponding figures for audit 1078 showed 6 (6%) and 8 (8%), respectively. These last figures were considered suspect because of apparent problems with the audit samples. Figure 4 shows a running tally of the above values.

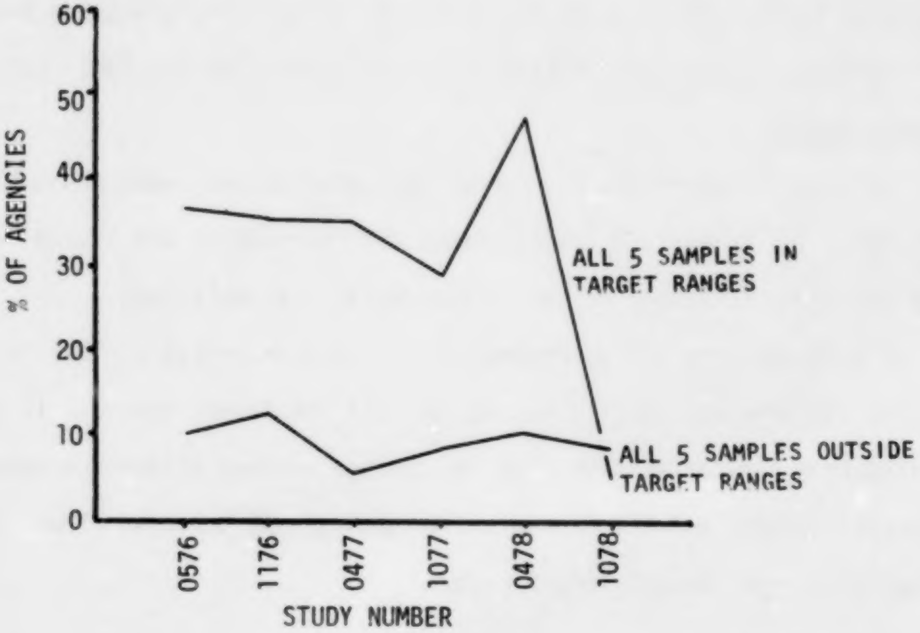

Figure 4. Plot of SO_2 Results (five samples within and outside Target Ranges).

Data Summary

After using Target ranges as one means of eliminating nonrepresentative data, it was decided that laboratories reporting all 5 results outside the Target ranges (i.e., results greater than $\pm 20\%$ of the EPA values) would be removed from the data base and excluded from further evaluations. The Target ranges are broad enough that, unless the determination is totally out of control, at least one value should fall within the ranges if the laboratory is performing adequately in comparison to most of the study population. If the agency was not performing well, its data was excluded from the summaries.

This discussion will be concerned with the reported results minus the data sets meeting the exclusion criterion. These data points are marked in the Appendix by an asterisk (*).

Table 9 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following equation:

$$\text{absolute percent difference} = \left| \frac{\text{reported value - EPA value}}{\text{EPA value}} \right| \times 100 \quad (4)$$

A frequency distribution was then constructed and appears below. For example, for audit 0478, 50 percent of the reported results for sample concentration 1 were less than or equal to an absolute percent difference of 15.2 percent. Note that the "All samples" line is not an average of the values appearing above it, but is the resulting distribution when all data is compiled, regardless of concentration.

The data in Table 9 are very useful for laboratories trying to determine their relative performance. For example, for audit 0478, only 10 percent of the labs reporting for concentration 1 had a percent difference of 2.3 percent or less, while 50 percent of the laboratories reported a percent difference of 15.2 percent or less. Table 9 also indicates the average percent difference for all laboratories for all samples. These are presented graphically in Figure 5 along with corresponding values from previous audits.

TABLE 9. SO_2 ABSOLUTE PERCENT DIFFERENCE

Concentration	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
SO_2 audit - 0478									
1	107	0.0	2.3	7.5	15.2	29.0	49.3	1022.9	30.9
2	113	0.0	0.6	3.3	6.4	10.5	18.6	60.5	9.5
3	112	0.1	0.9	2.7	5.9	10.3	21.5	68.6	10.3
4	112	0.3	1.7	3.0	5.2	7.8	16.8	58.5	8.7
5	112	0.0	1.1	2.8	5.8	10.0	24.2	89.2	11.6
All samples	556	0.0	1.0	3.4	6.6	11.7	30.9	1022.9	14.0
SO_2 audit - 1078									
1	86	3.6	11.5	39.2	55.1	73.3	152.2	374.1	71.3
2	92	0.1	1.2	5.5	10.5	18.9	44.2	81.6	18.4
3	91	0.2	1.3	4.4	8.9	13.4	18.4	54.6	10.9
4	90	0.1	1.4	3.1	5.0	7.9	16.8	38.7	7.6
5	91	0.8	4.3	7.9	11.9	16.0	22.3	42.6	12.9
All samples	450	0.1	2.0	6.0	11.7	18.9	58.5	374.1	23.7

All data received (except omitted data) were grouped according to concentration. The results for each sample value are listed in the Appendix in increasing concentration. Summary statistics which appear in Table 10 and at the top of each listing in the Appendix do not include outliers.

Table 10 tabulates the summary statistics based on the reported data. The "Outliers removed" columns contain data on which the outlier criterion was applied; all data meeting the second criterion (see Statistical Approach

Section) were removed. Note that the variation in the number of samples from concentration to concentration is due to laboratory accidents and damaged samples.

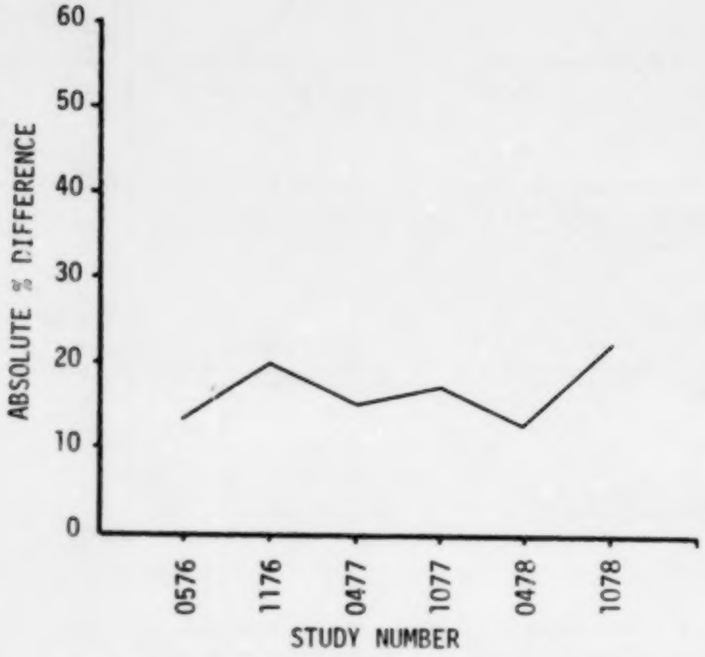

Figure 5. Plot of SO_2 absolute percent differences.

An examination of Tables 9 and 10 reveal that there were no apparent problems with Audit 0478. Except for concentration 1, 50 percent of the laboratories had percent differences of less than 10 percent. Accuracy and skewness values also indicate a normal distribution and acceptable accuracies.

TABLE 10. SO_2 SURVEY STATISTICS ($\mu g/m^3$)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5	
	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed
SO_2 Audit - 0478										
Number	107	106	113	110	112	109	112	108	112	109
True value	21.7	21.7	43.0	64.4	64.7	64.7	126.2	126.2	204.0	204.0
Mean	20.7	18.6	62.6	63.5	64.0	65.1	120.8	121.6	190.4	194.7
Median	19.5	19.5	64.1	64.3	65.0	65.0	121.3	121.6	197.0	197.5
Range	242.0	32.8	57.9	44.0	73.0	58.2	146.0	83.8	271.3	212.0
Std. dev.	22.5	5.6	9.0	7.2	10.8	8.4	16.6	11.8	38.9	29.6
Coef. var.	108.4	30.0	14.3	11.3	16.8	13.0	13.7	9.7	20.4	15.2
Skewness*	9.1	-0.3	-1.4	-0.4	-1.2	0.2	0.1	0.3	-1.9	-0.8
Accuracy+	-10.1	-10.1	-0.5	-0.2	0.5	0.5	-3.9	-3.6	-3.4	-3.2
SO_2 audit - 1078										
Number	86	85	92	90	91	88	90	86	91	89
True value	9.1	9.1	38.8	38.8	88.9	88.9	128.3	128.3	192.2	192.2
Mean	14.1	13.7	36.9	36.8	82.5	83.0	125.6	125.7	169.6	169.7
Median	13.2	13.1	38.0	38.0	81.9	82.1	125.7	125.7	169.3	169.3
Range	42.4	29.8	61.6	53.3	74.3	47.6	89.9	59.0	116.3	78.8
Std. dev.	7.0	6.3	10.4	9.4	11.2	9.2	13.9	10.6	18.0	15.9
Coef. var.	49.8	45.8	28.1	25.5	13.6	11.1	11.1	8.4	10.6	9.4
Skewness*	1.0	0.4	0.0	-0.2	-0.2	0.5	-0.4	-0.4	0.0	0.0
Accuracy+	45.5	44.5	-2.2	-2.2	-7.9	-7.7	-2.0	-2.0	-11.9	-11.9

*A statistic indicating the lack of symmetry in a distribution. For a normal distribution this value is near zero.

+$\frac{\text{Median - True value}}{\text{True value}}$ x 100

Tables 9 and 10 indicated serious problems with Audit 1078 results. The percent differences for concentrations 1 and 5 were not consistent with previous values (Table 9). A comparison in Table 10 of the true value and the median also indicate a discrepancy. In past surveys, the median has been an excellent indicator of the true value. Skewness values indicate that the results are normally distributed.

A discrepancy of this magnitude indicates a problem existing with either the samples or the EPA analysis. An investigation revealed that for concentrations 1 and 5, corroborative analyses provided by a contractor yielded results much closer to the survey median. Analysis from both groups showed an unusually large number of outlier samples. Reanalysis by EPA after the audit was completed also yielded values nearer the study median but still quite variable.

Because of the sample variability, it was difficult to determine whether the EPA analyses were incorrect or a series of bad samples were analyzed. To prevent further occurrences of this nature, more stringent acceptance controls are being instituted. Audit results will be reported for informational purposes only and will not be used in future accuracy or precision calculations.

Each laboratory data set was plotted against its corresponding EPA data set, and the slope and intercept of the linear regression line were determined. For Audit 0478, the mean of 113 slopes was 1.015 with a standard deviation of 0.234; the mean intercept was 3.90 with a standard deviation of 18.00. Audit 1078 had a mean slope of 1.138 with a standard deviation of 0.132; the mean intercept was -5.52 with a standard deviation of 10.87. Figure 6 shows a graphical plot of these results.

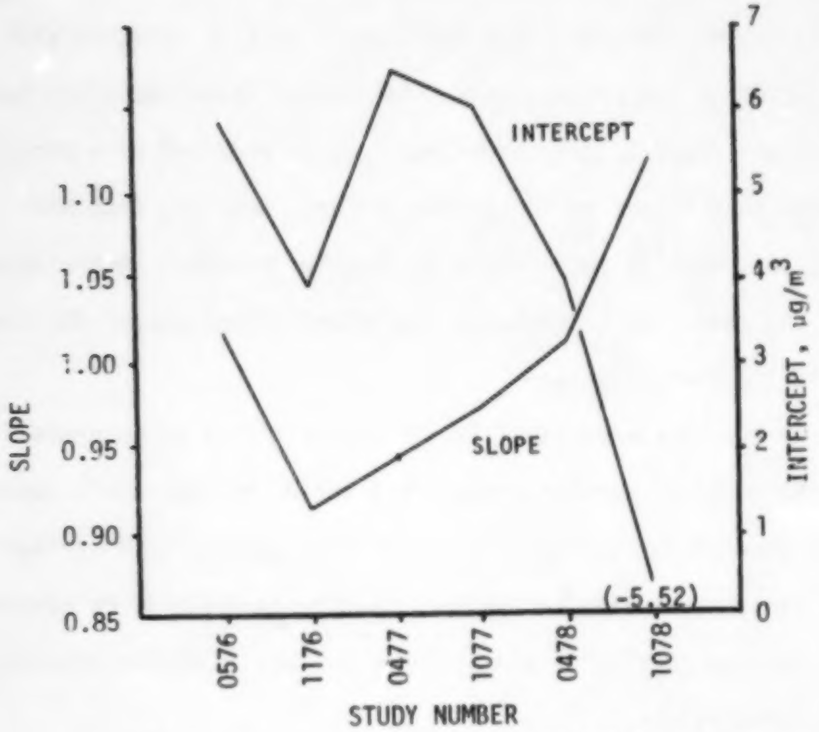

Figure 6. Plot of SO_2 slope and intercept.

Analytical Method Summary

A check was made to determine whether sets excluded from the summary were related to the method of analysis (i.e., was one method responsible for most of the data outliers, Table 11).

TABLE 11. SUMMARY OF SO_2 ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total number using method	Number identified as outliers	Percent of total as outliers
SO_2 audit - 0478			
Pararosaniline-manual	93	8	9
Pararosaniline-automated	29	2	7
Other	3	2	67
SO_2 audit - 1078			
Pararosaniline-manual	79	7	9
Pararosaniline-automated	21	1	5
Other	0	0	0

As shown, no one method contributed to the unusually large portion of outlier data.

To determine whether a particular analytical method produced biased results, Table 12 was developed. This table contains the mean and standard deviation of each concentration for each procedure used. No pattern was established in any of the audits.

Recheck Program

Laboratories reporting at least 3 results greater than ±20 percent of the EPA values were sent a second set of samples. This procedure would distinguish between labs having chronic problems and those who just had a "bad day." For audit 0478, 25 laboratories received a second set of samples. Of

TABLE 12. MEAN AND STANDARD DEVIATION OF SO_2 RESULTS BY ANALYTICAL METHOD ($\mu g/m^3$)

	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
SO_2 audit - 0478										
Manual	20.8	25.6	62.2	9.0	64.4	9.5	119.5	18.0	191.5	34.8
Automated	17.7	7.0	63.8	9.1	64.2	11.6	124.1	10.6	185.8	50.2
Other	10.5	0.0	60.3	0.0	21.0	0.0	141.5	0.0	225.3	0.0
True value	21.7		64.4		64.7		126.2		204.0	
SO_2 audit - 1078										
Manual	13.9	7.5	36.6	10.9	83.3	9.5	125.2	14.4	170.3	16.7
Automated	12.4	6.8	38.2	8.5	79.5	16.2	126.8	12.1	167.2	22.0
True value	9.1		38.8		88.9		128.3		192.2	

the 11 groups returning data, 5 had corrected their problems to the extent that at least 3 of their samples fell within ±20 percent of the EPA values.

Twenty-one laboratories received recheck samples for audit 1078. Eleven of these groups returned data, 7 of which had corrected their problems so that at least 3 samples fell within ±20 percent of the EPA values.

Only one agency received recheck samples for both audits. Thus, it appears that a small percentage of the agencies performing SO_2 analysis still have basic analytical problems. It is also evident that many of the problems uncovered during the initial analysis were corrected before the recheck samples were received.

Summary

The SO_2 audit starting dates covered in this report were April and October, 1978. The number of participants varied from 100 to 125. Foreign, EPA, State, local, and private laboratories submitted data.

Three analytical methods were used. The majority of the laboratories in both audits used the manual pararosaniline method. Approximately 22 percent of the laboratories used the automated pararosaniline procedure.

The overall results of audit 0478 showed no bias of any practical significance between reported and EPA values. The statistical distribution appeared to be normal. Large discrepancies in audit 1078 were noted, and were apparently due to analytical errors or questionable sample materials.

The average slopes (reported vs. EPA) for each audit ranged from 1.105 to 1.138. Intercepts varied from 3.90 to -5.52 $\mu g/m^3$.

AMBIENT NITROGEN DIOXIDE

Participant Characteristics

Nitrogen dioxide audit, number 0678, began in June 1978. Out of 122 sample sets requested by participants, 89 sets of data were returned for a response rate of 73 percent. Audit number 1278 began in December 1978. Out of 95 sample sets requested, 77 sets of data were returned for a response rate of 81 percent.

Table 13 indicates the monitoring agency distribution.

TABLE 13. NO_2 AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
NO_2 audit - 0678						
Agencies requesting samples	1	4	45	55	17	122
Agencies returning data	1	1	37	42	8	89
NO_2 audit - 1278						
Agencies requesting samples	1	1	34	47	12	95
Agencies returning data	0	0	32	38	7	77

Analytical methods were grouped into six broad categories. Table 14 lists the procedures used and their corresponding number of respondents.

TABLE 14. NO_2 ANALYTICAL METHODS

Method	Agencies using method	
	Audit 0678	Audit 0677
Saltzman-manual	4	4
Saltzman-automated	2	1
Sodium arsenite-manual	59	52
Sodium arsenite-automated	19	17
TGS - ANSA-manual	2	2
Other	3	1

A laboratory reporting usage of the manual sodium arsenite procedure as the method of choice may have used that procedure with various modifications. Thus, in Table 14, 59 laboratories employed a procedure approximating the manual sodium arsenite method during audit 0678.

Acceptable Ranges

Two performance ranges were used as one means available for judging performance. The Sample and Target ranges for NO_2 are listed in Table 15 and apply to sample values in increasing concentrations.

TABLE 15. NO_2 SAMPLE AND TARGET RANGES(%)

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5
Sample range	±10	±10	±10	±10	±10
Target range	±20	±20	±20	±20	±20

Neither the Sample nor the Target range was determined using the method described under Statistical Approach. Both ranges were arbitrarily set at the values listed in Table 15. As more audits are conducted and more data becomes available, the ranges will be refined.

Using the above criteria, a tabulation was made of the agencies obtaining results within the ranges. For audit 0678, a total of 68 (76%) agencies reported all 5 results within the Target ranges, while 5 (6%) laboratories reported all results outside these ranges. Corresponding figures for audit 1278 showed 60 (79%) and 4 (5%), respectively. Figure 7 shows a running plot of those values.

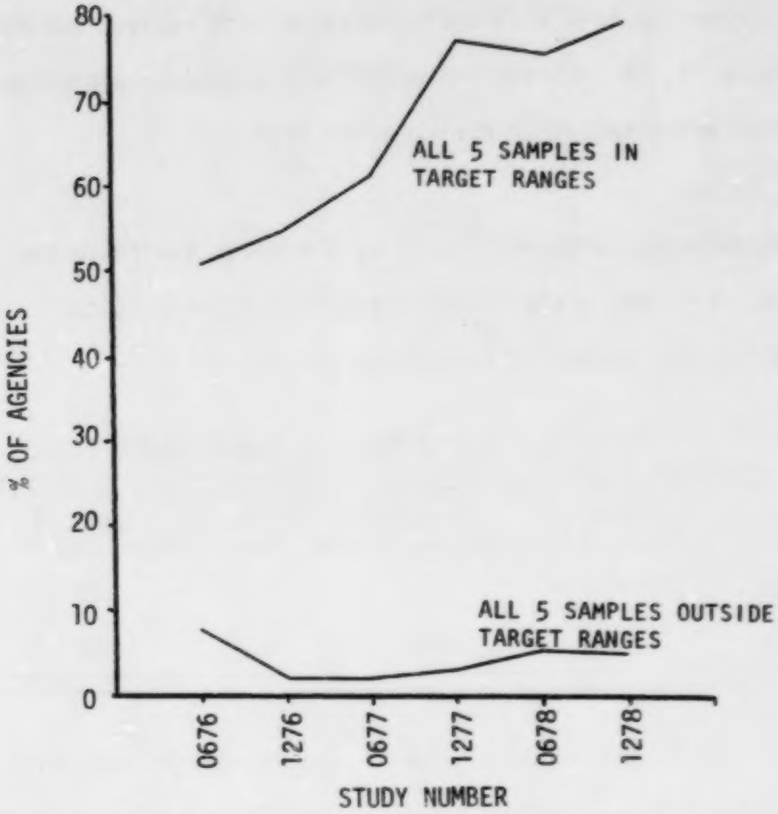

Figure 7. Plot of NO_2 results (5 samples within and outside Target Ranges).

Data Summary

It was decided that any laboratory not reporting at least one value within the Target ranges would be considered an outlier. Thus, if an agency is not performing adequately, its data was excluded in the summaries. The remainder of this discussion will deal with the reported results minus the values identified as outliers. The values identified as outliers are noted in the Appendix by an asterisk (*).

Table 16 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{absolute percent difference} = \left|\frac{\text{reported value - EPA value}}{\text{EPA value}}\right| \times 100.$$

The frequency distribution was then constructed and appears in Table 16. It should be noted that the "All samples" line is not an average of the numbers appearing above it, but is the distribution resulting from the total compilation of data.

Table 16 is also very useful for laboratories trying to determine their performance relative to the other participants. For example, in audit 0678, only 10% of the labs reporting results for concentration 1 had a percent difference of 0.8 or less, while 50% of the laboratories reported a percent difference of 4.8 or less for the same concentration. The table also indicates the average percent difference for all laboratories for all samples. These values are shown in Figure 8 along with corresponding numbers from previous studies.

TABLE 16. NO_2 ABSOLUTE PERCENT DIFFERENCE

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
NO_2 audit - 0678									
Conc. 1	82	0.0	0.8	3.2	4.8	8.7	15.9	98.4	8.5
Conc. 2	84	0.0	0.8	4.2	5.5	8.0	15.6	55.5	7.5
Conc. 3	84	0.0	0.8	3.8	5.8	7.5	13.8	54.2	7.4
Conc. 4	83	0.3	1.6	3.5	4.6	7.0	9.9	34.0	6.0
Conc. 5	82	0.2	0.9	2.0	3.8	5.1	8.7	43.7	4.9
All samples	415	0.0	1.1	3.3	5.0	7.5	13.5	98.4	6.9
NO_2 audit - 1278									
Conc. 1	72	0.0	0.8	3.4	6.8	8.0	13.3	37.9	7.8
Conc. 2	72	0.0	0.3	2.1	3.6	5.7	10.6	19.3	4.9
Conc. 3	69	0.2	0.4	1.4	3.7	5.6	11.8	24.2	5.2
Conc. 4	72	0.0	0.3	1.4	2.9	3.7	7.6	19.9	3.8
Conc. 5	72	0.2	0.6	1.3	2.7	3.9	10.4	51.5	4.5
All samples	357	0.0	0.6	1.9	3.4	5.7	11.7	51.5	5.2

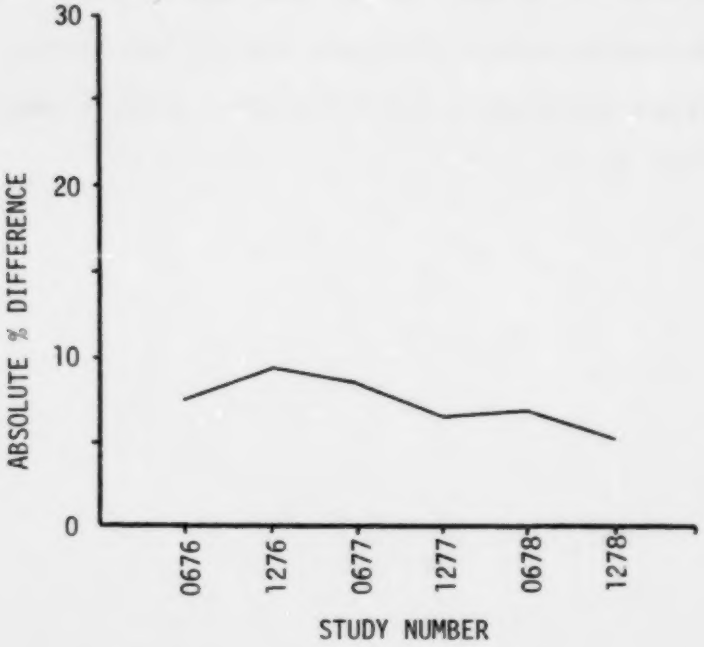

Figure 8. Plot of NO_2 absolute percent differences.

All data received (except omitted data) were grouped according to concentration. The results for each sample are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 17 and at the top of each listing in the Appendix do not include outliers.

Table 17 lists summary statistics. The "Outliers removed" columns contain data on which outlier criterion was applied. All data that met the second criterion stated in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents and damaged samples. With the exception of one sample (Table 17), all accuracy figures were less than ±5 percent. All concentrations were normally distributed. The overall accuracy of audit 1278 was superior to audit 0678.

Individual data sets were plotted against corresponding EPA values, and the slope and intercept of their linear regressions were determined. For audit 0678, the mean of 84 slopes was 0.988 with a standard deviation of 0.094; the mean intercept was -0.007 with a standard deviation of 0.025. Audit 1278 had a mean slope of 0.994 with a standard deviation of 0.063; the mean intercept was -0.001 with a standard deviation of 0.030. Figure 9 illustrates a tally of these results.

TABLE 17. NO_2 SURVEY STATISTICS (μg/ml)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5	
	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed
NO_2 audit - 0678										
Number	82	81	84	82	84	83	83	80	82	80
True value	0.13	0.13	0.24	0.24	0.24	0.24	0.37	0.37	0.69	0.69
Mean	0.13	0.13	0.25	0.25	0.25	0.25	0.39	0.39	0.71	0.71
Median	0.13	0.13	0.25	0.25	0.25	0.25	0.39	0.39	0.71	0.71
Range	0.15	0.08	0.18	0.10	0.16	0.09	0.18	0.08	0.43	0.19
Std. dev.	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.03
Coef. var.	14.10	9.80	8.90	5.71	8.61	6.99	6.28	4.43	7.03	4.22
Skewness*	3.55	0.82	1.58	0.15	1.96	0.39	1.28	-0.27	-3.34	0.52
Accuracy+	2.38	2.38	5.04	5.04	4.58	4.58	4.02	4.02	3.05	3.19
NO_2 audit - 1278										
Number	72	70	72	71	69	66	72	69	72	70
True value	0.26	0.26	0.39	0.39	0.52	0.52	0.70	0.70	0.93	0.93
Mean	0.27	0.27	0.39	0.39	0.52	0.52	0.71	0.70	0.94	0.94
Median	0.27	0.27	0.39	0.39	0.52	0.52	0.70	0.70	0.94	0.94
Range	0.14	0.11	0.13	0.12	0.22	0.15	0.26	0.18	0.74	0.27
Std. dev.	0.03	0.02	0.02	0.02	0.04	0.03	0.04	0.03	0.08	0.05
Coef. var.	9.74	8.30	6.35	6.03	7.38	5.71	5.67	4.47	8.40	4.79
Skewness*	1.01	0.41	0.09	-0.15	-0.73	0.48	0.72	0.82	-2.75	0.04
Accuracy+	2.55	2.65	0.52	0.52	0.78	0.97	0.00	0.00	0.91	0.91

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*A statistic indicating lack of symmetry in a distribution. For a normal distribution this value is near zero.

$^{+}\dfrac{\text{Median - True value}}{\text{True value}} \times 100$

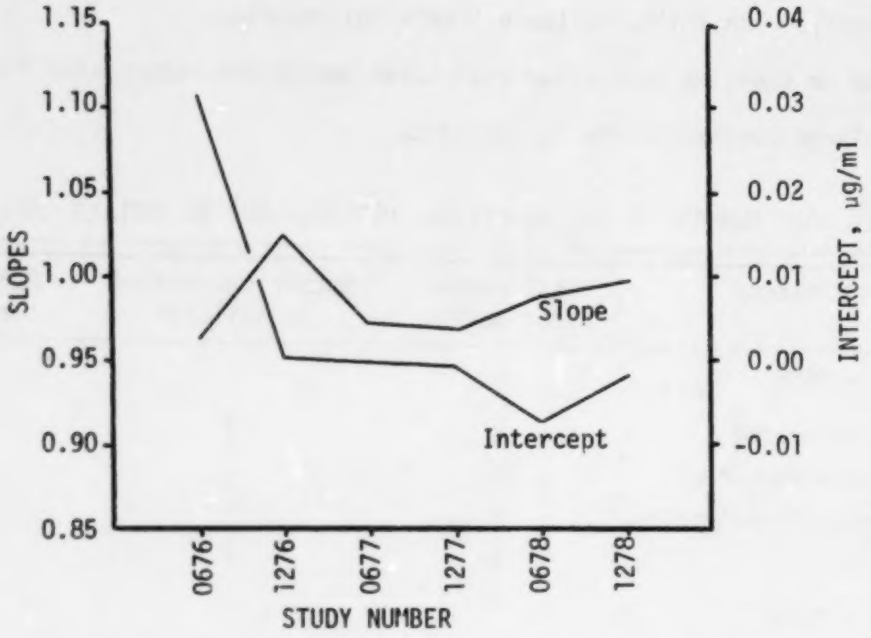

Figure 9. Plot of NO_2 slope and intercept.

Analytical Method Summary

A check was made to determine whether any relationship existed between the laboratories whose data were omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). The following table (Table 18) resulted.

As can be seen, no particular analytical method was responsible for an unusually large portion of the outlier data.

TABLE 18. SUMMARY OF NO_2 ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total number using method	Number identified as outliers	Percent of total as outliers
NO_2 audit - 0678			
Saltzman-automated	2	1	50
Sodium Arsenite-manual	59	2	3
Sodium Arsenite-automated	19	1	5
Other	3	1	33
NO_2 audit - 1278			
Saltzman-automated	1	1	100
Sodium Arsenite-manual	52	2	4
TGS-ANSA-manual	2	1	50

To determine whether a particular analytical method produced biased results, Table 19 was developed. This table contains the mean and standard deviation of each sample concentration for each method used. As can be seen, both major methods estimated the true concentration well and both were equally precise.

Recheck Program

Laboratories reporting 3 or more results greater than ±20 percent of the

TABLE 19. MEAN AND STANDARD DEVIATION OF NO_2 RESULTS BY ANALYTICAL METHOD (µg/ml)

Method	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
NO_2 audit - 0678										
Saltzman-man.	0.13	0.00	0.25	0.01	0.25	0.01	0.38	0.01	0.68	0.01
Saltzman-auto.	0.13	-	0.25	-	0.25	-	0.40	-	0.73	-
Sodium arsenite-man.	0.13	0.02	0.25	0.02	0.26	0.02	0.39	0.03	0.72	0.03
Sodium arsenite-auto.	0.13	0.01	0.24	0.01	0.25	0.02	0.38	0.02	0.68	0.08
TGS - ANSA-man.	0.13	0.02	0.24	0.03	0.25	0.03	0.39	0.04	0.69	0.08
Other	0.11	0.02	0.23	0.02	0.23	0.02	0.37	0.02	0.68	
True value	0.13		0.24		0.24		0.37		0.69	
NO_2 audit - 1278										
Saltzman-man.	0.26	0.02	0.38	0.03	0.51	0.02	0.72	0.06	0.97	0.05
Sodium arsenite-man.	0.27	0.03	0.39	0.02	0.52	0.04	0.70	0.03	0.93	0.08
Sodium arsenite-auto.	0.28	0.03	0.39	0.03	0.52	0.05	0.70	0.05	0.94	0.06
TGS - ANSA-man.	0.27	-	0.38	-	0.52	-	0.68	-	0.92	-
Other	0.32	-	0.43	-	0.55	-	0.74	-	1.04	-
True value	0.26		0.39		0.52		0.70		0.93	

EPA values was sent a second set of samples. For audit 0678, 7 laboratories received a second set. Of the 7 groups returning data, 3 had corrected their problem to the extent that at least 3 samples fell within ±20 percent of EPA values.

Four laboratories received recheck samples for audit 1278. One of these groups returned data, however, their values remained unacceptable.

Summary

Nitrogen dioxide audit dates were June and December, 1978. The number of participants varied from 95 to 122. Foreign, EPA, State, local, and private laboratories submitted their results.

Six analytical methods were employed. In both audits, the majority of laboratories used the manual sodium arsenite procedure. Approximately 20 percent of the laboratories used the automated sodium arsenite procedure.

Overall results revealed no bias of any practical significance between the reported and EPA values. The data from each audit appeared to be normally distributed.

The average slopes (reported vs. EPA) for each audit ranged from 0.98 to 0.99 and intercepts varied from 0.001 to -0.007 μg/ml.

AMBIENT CARBON MONOXIDE

Participant Characteristics

Carbon monoxide audit, number 0378, began in March, 1978. Out of 145 agencies requesting samples, 117 returned data for a response rate of 81 percent. Three hundred twenty-seven instruments were tested. Audit 0978 began in September, 1978. Out of 149 agencies requesting samples, 122 returned data for a response rate of 82 percent. A total of 318 CO monitors were audited. Table 20 indicates the monitoring agency distribution.

Methods used to analyze the samples were grouped into three categories. Table 21 lists the analytical methods used and the number of instruments using the method.

TABLE 20. CO AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
CO Audit - 0378						
Agencies requesting samples	3	8	53	77	4	145
Agencies returning data	3	6	44	63	1	117
CO audit - 0978						
Agencies requesting samples	2	8	59	75	5	149
Agencies returning data	2	4	49	65	2	122

TABLE 21. CO ANALYTICAL METHODS

Method	Analyzers using method	
	Audit 0378	Audit 0978
NDIR	280	268
FID	42	40
Other	5	4

Most instruments classified as "Other" used an electrochemical method of detection.

Agencies generally employ a liberal interpretation of the analytical method used. However, in the case of CO analyses, the methods are clearly defined. Unknowns possibly effecting results and which are considered part of the analytical system are the purity of zero air, and the accuracy of calibration standards.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample and Target ranges for the audits are listed in Table 22 and apply to concentrations in ascending order.

TABLE 22. CO SAMPLE AND TARGET RANGES (%)

	Concentration 1	Concentration 2	Concentration 3
CO audit - 0378			
Sample range	± 7.0	± 2.5	± 1.2
Target range	±10	±10	±10
CO audit - 0978			
Sample range	±13.1	± 3.4	± 1.4
Target range	±13.1	±10	±10

Sample ranges were not determined by the method described under Statistical Approach. Because filling of the cylinders was done so precisely, standard deviations of the verification analyses were small. Thus, using the procedure described in the Statistical Approach section resulted in unreasonably small Sample ranges for all concentrations. Rather than use unrealistic values, the Sample ranges were set at a QAD determined value ±0.5 ppm.

Target ranges were determined from previous CO audit results. Earlier studies indicated that the average percent difference between reported results and EPA determined values for all concentrations was ±10 percent. This value has been used for all Target ranges with the exception of concentration 1. In that particular case, the Sample range was applied due to its larger value.

A tabulation was made of the instruments reporting results within the ranges. For audit 0378, a total of 222 instruments (68%) reported all values within the Target ranges, while 5 instruments (2%) reported all results outside the Target ranges. Corresponding values for audit 0978 showed 166 (52%) and 11 (3%), respectively. Figure 10 shows a graphical plot of those values.

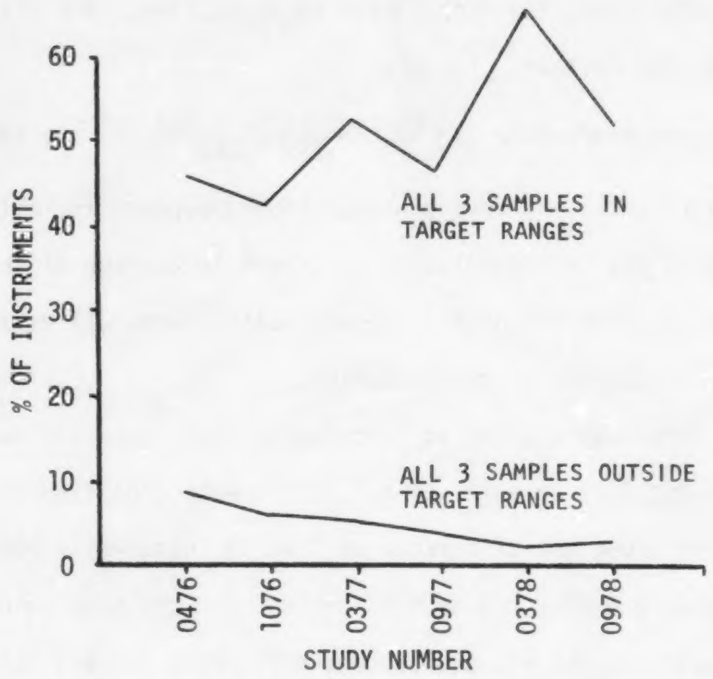

Figure 10. Plot of CO results (3 samples within and outside Target ranges).

Data Summary

Any instrument not reporting at least one value within the Target ranges was considered an outlier and was not included in the data summaries. The remainder of the discussion will deal with the reported results minus the values identified as outliers. These results are eliminated from further data summaries. The values identified as outliers are indicated in the Appendix by an asterisk (*).

Table 23 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{absolute percent difference} = \left|\frac{\text{reported value - EPA value}}{\text{EPA value}}\right| \times 100.$$

The frequency distribution was then constructed and appears in Table 23. It should be noted that the "All Samples" line is not an average of the numbers appearing above it, but is the distribution resulting when all data is examined together regardless of concentration.

Table 23 assists laboratories in determining their relative performance. For example, in audit 0378 only 10% of the instruments reporting results for concentration 1 had a percent difference of 1.4% or less, while 50% of the instruments reported a difference of 4.9% or less for the same concentration. The table also indicates the average percent difference for all instruments for all samples. These values are illustrated in Figure 11 along with corresponding values from previous audits.

TABLE 23. ABSOLUTE PERCENT DIFFERENCE

Concentration	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
CO audit - 0378									
1	319	0.1	1.4	2.1	4.9	9.1	16.1	555.9	9.4
2	321	0.1	0.4	1.1	1.8	3.8	7.3	19.9	3.2
3	317	0.1	0.2	0.8	1.6	3.1	6.4	88.7	3.1
All samples	957	0.1	0.4	1.3	2.3	4.9	11.0	555.9	5.2
CO audit - 0978									
1	301	0.3	2.1	4.7	9.3	16.2	30.1	161.8	14.1
2	301	0.0	0.4	1.9	3.0	5.8	9.3	198.1	5.1
3	301	0.1	0.1	1.2	2.0	3.2	6.2	54.7	2.9
All samples	903	0.0	0.4	2.1	3.8	7.1	16.8	198.1	7.4

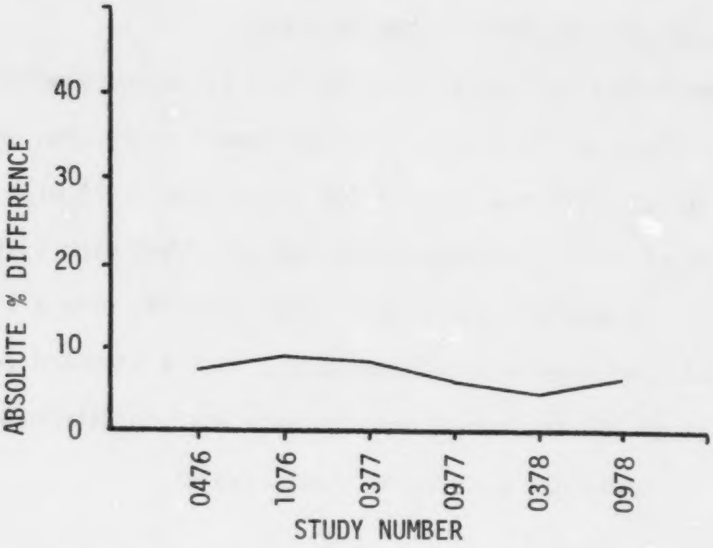

Figure 11. Plot of CO absolute percent differences.

The results for each sample value are listed in the Appendix, in increasing concentration. The summary statistics which appear in Table 24 and at the top of each listing in the Appendix do not include outliers.

Table 24 lists summary statistics based on the reported data. The "Outliers removed" column contains data on which the outlier criterion was applied. All data that met the second criterion in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents and damaged samples.

An examination of Table 24 reveals no bias or skewness problems in any of the audits. The greatest inaccuracy was -6.5 percent. The near zero value of the skewness indicator shows that the distribution was normal.

The EPA determined true value and the median of the study results agree well. This is indicated by accuracy values. The study population is normally distributed as indicated by the skewness.

Each instrument data set was plotted against its corresponding EPA data set, and the slope and intercept from the linear regression were determined. For audit 0378, the mean of 322 slopes was 0.973 with a standard deviation of 0.175; the mean intercept was 0.545 with a standard deviation of 3.773. Audit 0978 had a mean slope of 0.978 with a standard deviation of 0.064; the mean intercept was 0.261 with a standard deviation of 1.277. A total of 307 instrument results were used to determine these values. Figure 12 represents a tally of these results.

TABLE 24. CO SURVEY STATISTICS

	Concentration 1		Concentration 2		Concentration 3	
	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed
CO audit - 0378						
Number	319	318	321	318	317	315
True value	7.2	7.2	20.2	20.2	42.1	42.1
Mean	7.1	6.9	20.3	20.4	42.2	42.4
Median	7.0	7.0	20.3	20.3	42.3	42.3
Range	42.9	6.1	7.2	6.0	42.6	13.6
Std. dev.	2.4	0.7	0.9	0.9	3.3	1.6
Coef. var.	33.4	10.7	4.6	4.3	7.8	3.7
Skewness*	15.1	-0.3	-0.6	-0.2	-8.6	-0.5
Accuracy[+]	-2.1	-2.1	0.4	0.5	0.5	0.6
CO audit - 0978						
Number	301	297	301	300	301	300
True value	3.8	3.8	14.6	14.6	36.4	36.4
Mean	3.6	3.6	14.8	14.7	36.9	37.0
Median	3.6	3.6	14.7	14.7	36.9	36.9
Range	8.5	4.5	32.1	7.7	25.5	9.4
Std. dev.	0.8	0.6	1.9	0.9	1.8	1.3
Coef. var.	22.1	16.8	12.7	6.0	4.8	3.5
Skewness*	2.9	0.5	11.8	0.3	-4.9	0.5
Accuracy[+]	-6.0	-6.5	1.0	1.0	1.2	1.2

*A statistic indicating a lack of symmetry in a distribution. For a normal distribution this value is near zero.

[+] $\frac{\text{median - true value}}{\text{true value}} \times 100$

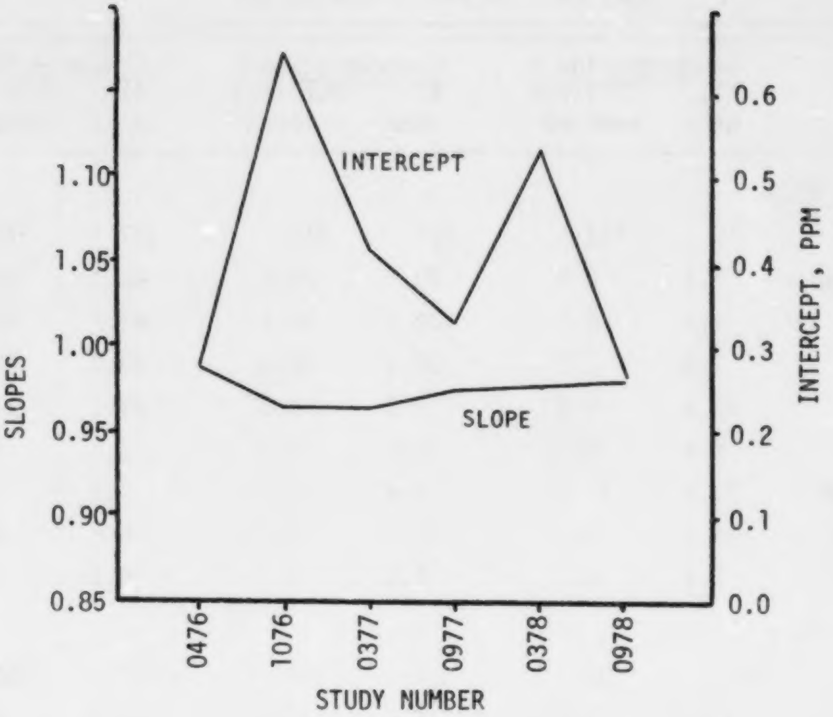

Figure 12. Plot of CO slope and intercept.

Analytical Method Summary

A check was made to determine whether any one method was responsible for most of the data outliers and resulted in Table 25. As can be seen, both of the predominately used procedures contributed only 5 percent or less of the outlier instruments.

To determine whether a particular analytical method produced biased results, Table 26 was developed. This table contains the mean and standard deviation of each sample concentration for each method employed.

TABLE 25. SUMMARY OF CO ANALYTICAL METHODS USED BY OUTLIER INSTRUMENTS

Method	Total no. using method	No. identified as outliers	Percent of total as outliers
CO audit - 0387			
NDIR	280	5	2
Flame ionization	42	0	0
Other	5	0	0
CO audit - 0978			
NDIR	268	9	3
Flame ionization	40	2	5
Other	4	1	25

TABLE 26. MEAN AND STANDARD DEVIATION OF CO RESULTS BY ANALYTICAL METHOD (PPM)

Method	Concentration 1		Concentration 2		Concentration 3	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
CO audit - 0378						
NDIR	7.0	0.8	20.4	0.8	41.8	5.1
Flame ionization	7.3	6.3	19.7	1.6	41.8	6.1
Other	7.5	0.9	20.7	0.8	42.2	3.0
True value	7.2		20.2		42.1	
CO audit - 0978						
NDIR	3.7	0.7	14.7	0.8	37.0	1.2
Flame ionization	3.4	0.6	15.1	4.8	36.5	3.9
Other	6.1	3.4	16.0	2.6	37.2	2.4
True value	3.8		14.6		36.4	

The data indicate that the NDIR and FID methods were equally accurate; however, the NDIR was more precise. The "Other" category was biased high, however, only 4 or 5 instruments submitted data.

Summary

The CO audit commencement dates covered in this report were March and September, 1978. Participants varied from 145 to 149; up approximately 3.0% from the previous year. Number of instruments checked varied from 318 to 327; also up approximately 3.0%. Foreign, EPA, State, local and private laboratories submitted data.

Three analytical methods were utilized. The majority of the instruments were NDIRs (approximately 85 percent).

Overall results showed no bias between the reported and EPA values, and results appeared to be normally distributed. Of the three procedures used, the NDIR and FID techniques seemed to yield equally accurate results. However, NDIR appeared to be slightly more precise. Average slopes (reported vs. EPA) for each audit varied from 0.973 to 0.978 with intercepts from 0.261 to 0.545.

HI-VOL SULFATE

Participant Characteristics

Sulfate audit number 0278 began in February, 1978. Out of 73 sample sets requested by participants, 49 sets of data were returned for a response rate of 67 percent. Audit 0878 began in August, 1978. Out of 84 sample sets requested, 58 sets of data were returned for a response rate of 69 percent.

Table 27 compiles the monitoring agency type distribution.

Methods used to analyze the samples were grouped into 9 broad categories. Results were received from laboratories using 5 methods and are listed in Table 28.

TABLE 27. $SO_4^=$ AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
$SO_4^=$ audit - 0278						
Agencies requesting samples	2	1	30	23	17	73
Agencies returning data	1	1	20	16	11	49
$SO_4^=$ audit - 0878						
Agencies requesting samples	2	3	32	26	21	84
Agencies returning data	2	2	26	17	11	58

TABLE 28. $SO_4^=$ ANALYTICAL METHODS

Method	Agencies using method	
	Audit 0278	Audit 0878
Methylthymol blue - automated	16	18
Barium chloride - manual	21	25
Barium chloride - automated	1	3
Sulfa-ver - manual	8	9
Other	3	3

It should be noted that some agencies tend to define the analytical methods used in very general terms. A laboratory reporting usage of the automated methylthymol blue procedure may have used that procedure with various modifications. Thus, Table 28 should be interpreted as 16 laboratories in audit 0278 having used procedures approximating the automated methylthymol blue method.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample and Target ranges are listed in Table 29 and apply to sample concentrations in ascending order.

TABLE 29. $SO_4^=$ SAMPLE AND TARGET RANGES (%)

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Sample range	± 5	± 5	± 5	± 5	± 5	± 5
Target range	±15	±15	±15	±15	±15	±15

Neither the Sample nor Target ranges were determined using Statistical Approach methods. Both were arbitrarily set at the values listed in Table 29. As more audits are conducted and more data become available, the ranges will be refined.

Using those criteria, a tabulation was made of the agencies reporting results within the ranges. For audit 0278, 12 (24%) agencies reported 5 or 6 results within the Target ranges, while 5 (10%) laboratories reported all results outside these ranges. Corresponding figures for audit 0878 showed 19 (33%) and 3 (5%), respectively. Figure 13 illustrates a graphical plot of those values.

Data Summary

Using the Target ranges as one means of eliminating nonrepresentative data, it was decided that any laboratories not reporting at least one value within the Target ranges were considered outliers. Labs performing inadequately were excluded from the summaries. Five laboratories met the criterion for outlier rejection in 0278 and 3 in 0878.

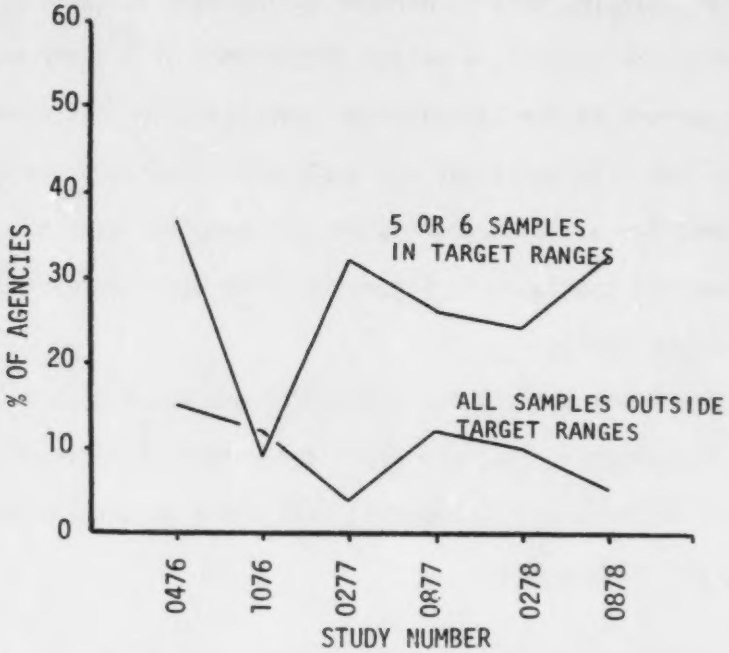

Figure 13. Plot of $SO_4^=$ results (5 or 6 samples within Target ranges and 6 samples outside Target ranges).

Table 30 is a frequency distribution of the percent difference between reported and EPA values for each concentration. The differences were calculated using the following formula:

$$\text{absolute percent difference} = \left|\frac{\text{reported value - EPA value}}{\text{EPA value}}\right| \times 100.$$

The frequency distribution was then constructed and appears in Table 30. It should be noted that the "All Samples" line is not an average of the numbers appearing above it, but is the distribution resulting when all data is examined together regardless of concentration.

Table 30 is helpful to laboratories trying to determine their relative performance. For example, only 10 percent of the labs in audit 0278 reporting results for concentration 3 had a percent difference of 3.3 percent or less, while 50 percent of the laboratories reported a percent difference of 12.2 percent or less. In addition, the table also indicates the average percent difference for all laboratories for all samples (except concentration 1). These values are tabulated in Figure 14 along with corresponding values from previous audits.

Concentration 1 was a blank for audit 0278 and was excluded in the "All samples" distribution. Because small concentration differences result in large percent differences, it was felt that those particular values would unduly distort the study results.

TABLE 30. $SO_4^=$ ABSOLUTE PERCENT DIFFERENCE

Concentration	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
$SO_4^=$ audit - 0278									
1	BLANK								
2	41	0.0	3.9	11.1	19.4	44.4	88.9	521.7	47.3
3	43	0.0	3.3	7.4	12.2	27.8	55.6	191.1	28.2
4	43	0.0	0.2	2.1	5.0	10.7	19.7	95.0	11.0
5	44	0.0	0.3	1.9	5.4	8.5	21.7	94.9	9.8
6	44	0.0	0.3	3.2	6.5	9.9	15.6	94.8	9.9
All samples	215	0.0	0.8	4.4	8.9	15.6	48.2	521.7	20.9
$SO_4^=$ audit - 0878									
1	44	0.0	4.6	20.0	36.2	53.8	167.7	423.8	72.0
2	52	0.0	3.0	6.7	17.7	30.0	65.0	205.0	28.7
3	54	0.0	1.4	4.6	8.1	11.7	25.0	46.0	10.9
4	51	0.0	1.7	4.0	6.0	11.1	25.6	43.6	11.2
5	53	0.0	0.6	3.0	4.6	11.9	21.2	41.8	9.0
6	52	0.3	0.9	3.6	7.3	10.2	16.7	37.0	9.0
All samples	306	0.0	1.5	4.6	4.1	18.6	41.5	423.8	22.1

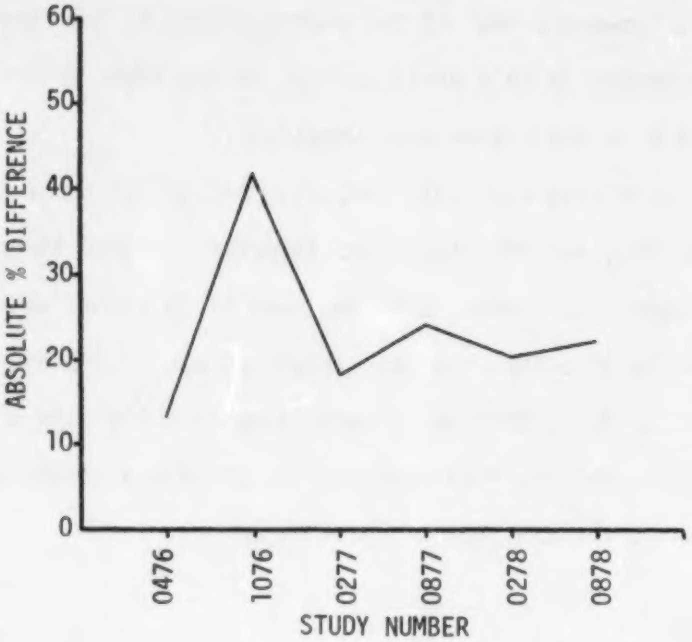

Figure 14. Plot of $SO_4^=$ absolute percent differences.

Results for each sample value are listed in the Appendix in order of increasing concentrations. The summary statistics in Table 31 and at the top of each listing in the Appendix do not include outliers.

Table 31 lists summary statistics based on reported data, and the "Outliers removed" column contains data on which an outlier test was applied. All data that met the second criterion in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents, damaged samples, and inclusion of duplicate samples.

An examination of Table 31 shows that all the data were normally distributed. Inaccuracy at some of the concentrations was larger than would be desired. However, most of the bias occurred at low concentrations. Generally, there tended to be a positive bias in the lower concentrations and a negative bias in the higher concentrations.

Individual laboratory data sets were plotted against their corresponding EPA data sets, and the slopes and intercepts of the linear regression line were determined. For audit 0278, the mean of 43 slopes was 1.031 with a standard deviation of 0.152; the mean intercept was -0.383 with a standard deviation of 1.353. Audit 0878 had a mean slope of 1.050 with a standard deviation of 0.151; the mean intercept was -0.324 with a standard deviation of 1.510. Figure 15 shows a plot of these results.

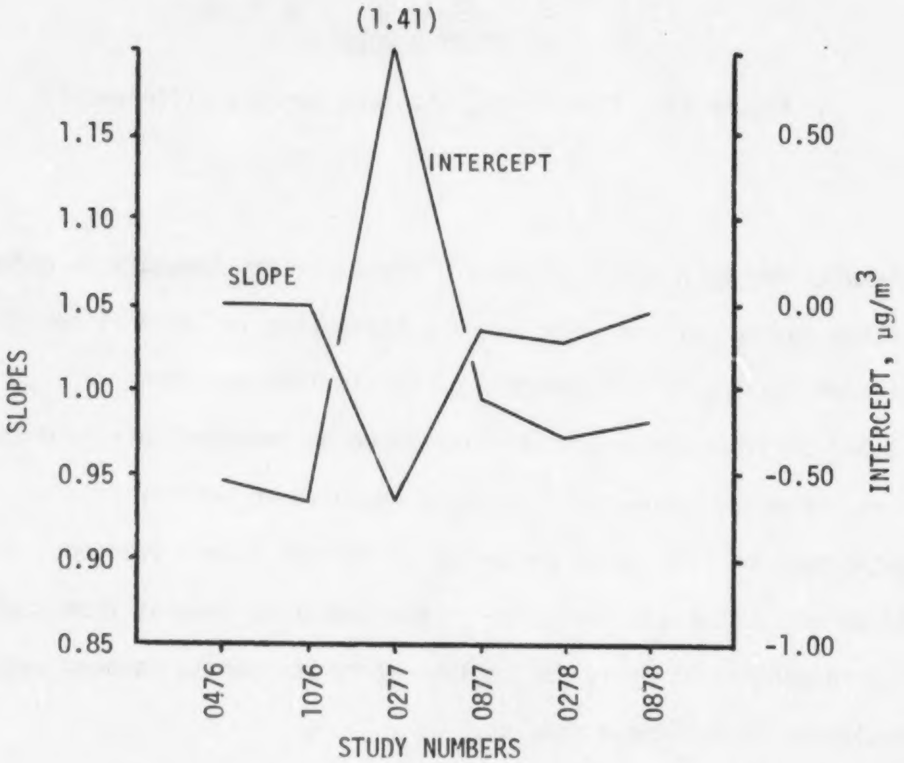

Figure 15. Plot of $SO_4^=$ slope and intercept.

TABLE 31. $SO_4^=$ SUMMARY STATISTICS ($\mu g/m^3$)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5		Concentration 6	
	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed
$SO_4^=$ audit - 0278												
Number	29	28	41	40	43	42	43	41	44	43	44	43
True value	0.00	0.00	1.80	1.80	2.70	2.70	9.60	9.60	12.00	12.00	14.40	14.40
Mean	1.26	1.07	2.26	2.04	2.91	2.80	9.22	9.60	11.56	11.82	13.92	14.23
Median	0.51	0.50	1.98	1.98	2.90	2.85	9.59	9.60	11.88	11.89	14.02	14.05
Range	6.59	4.60	11.01	4.43	7.68	5.74	11.12	4.25	14.06	6.52	17.52	9.34
Std. dev.	1.55	1.18	1.68	0.89	1.23	0.97	2.00	0.94	2.16	1.37	2.58	1.61
Coef. var.	122.91	110.52	74.16	43.51	42.25	34.71	21.72	9.76	18.70	11.55	18.55	11.34
Skewness*	1.90	1.63	3.66	0.52	1.46	0.25	-2.86	-0.01	-2.92	-0.42	-2.87	0.03
Accuracy+	-	-	10.00	10.00	7.41	5.74	-0.10	-0.00	-0.96	-0.92	-2.60	-2.43
$SO_4^=$ audit - 0878												
Number	44	42	52	50	54	53	51	51	53	52	52	51
True value	1.30	1.30	3.00	3.00	11.10	11.10	13.50	13.50	26.40	26.40	39.60	39.60
Mean	2.08	1.87	3.47	3.28	10.98	11.08	12.71	12.71	25.52	25.72	38.62	38.88
Median	1.68	1.64	3.15	3.12	10.94	10.95	12.90	12.90	25.65	25.67	38.36	38.40
Range	6.12	4.41	8.15	4.25	8.37	6.96	8.76	8.76	17.10	13.56	25.29	22.77
Std. dev.	1.34	0.94	1.31	0.90	1.62	1.48	1.98	1.98	3.25	2.95	21.58	4.27
Coef. var.	64.48	50.47	37.60	27.28	14.73	13.33	15.60	15.60	12.73	11.46	12.03	10.97
Skewness*	1.87	1.38	1.88	0.19	-0.36	0.05	-0.69	-0.69	-0.44	-0.01	-0.27	0.11
Accuracy+	29.23	26.15	5.00	4.00	-1.40	-1.35	-4.44	-4.44	-2.84	-2.75	-3.12	-3.03

*A statistic indicating the lack of symmetry in a distribution. For a normal distribution this value is near zero.

+ $\frac{\text{median - true value}}{\text{true value}} \times 100$

Analytical Method Summary

A check was made to determine whether any one method was responsible for most of the data outliers (Table 32).

TABLE 32. SUMMARY OF $SO_4^=$ ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total no. using method	No. identified as outliers	% of total as outliers
$SO_4^=$ audit - 0278			
Methylthymol blue - automated	15	1	7
Barium chloride - manual	18	3	17
Sulfa-ver - manual	7	1	14
$SO_4^=$ audit - 0878			
Barium chloride - manual	22	4	18

While no specific method was responsible for a large percentage of the outlier data, the manual barium chloride method was responsible for outlier data in both of the audits. Table 33 contains the means and standard deviations of each sample concentration for each method used.

In general, the automated methythymol blue procedure was superior in accuracy and precision. There was little difference in the accuracies of both barium chloride methods and the manual Sulfa-ver method. Automated barium chloride was more precise than manual barium chloride. None of the methods indicated a large bias.

Recheck Program

Starting with audit 0278, a recheck program was begun. Any laboratory reporting at least 3 results greater than ±15 percent of the EPA values was

TABLE 33. MEAN AND STANDARD DEVIATION OF $SO_4^=$ RESULTS BY ANALYTICAL METHOD ($\mu g/m^3$)

Method	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
$SO_4^=$ audit - 0278												
MTB - auto.	0.55	1.14	2.53	2.44	3.02	1.39	8.98	1.96	11.85	1.12	14.21	0.87
BaCl - man.	1.34	1.76	2.28	1.16	3.05	1.08	9.92	1.24	11.93	1.74	14.43	2.23
BaCl - auto.	0.40	0	2.60	0	4.20	0	8.50	0	11.20	0	13.40	0
Sulfa-ver - man.	0.48	0.84	1.35	1.00	2.19	1.40	9.43	0.70	11.66	1.17	14.08	1.33
Other	0.20	0.26	1.26	0.94	1.89	1.50	6.18	4.94	7.79	6.23	9.19	7.34
True value	0.00		1.80		2.70		9.60		12.00		14.40	
$SO_4^=$ audit - 0878												
MTB - auto.	1.46	0.76	3.26	0.66	10.90	0.86	12.76	1.19	24.14	3.16	36.95	4.14
BaCl - man.	2.04	2.04	3.65	2.00	10.85	2.08	12.56	2.39	25.68	3.15	39.14	5.17
BaCl - auto.	1.20	0.70	3.85	1.49	12.33	2.18	12.02	3.89	29.21	3.16	41.21	4.53
Sulfa-ver - man.	1.71	1.24	3.14	0.69	11.19	1.54	13.23	1.66	26.54	3.10	39.43	4.78
Other	1.61	0.23	2.89	0.14	10.48	0.45	2.89	0.14	25.37	0.10	38.76	1.98
True value	1.30		3.00		11.10		13.50		26.40		39.60	

sent a second set of samples. For audit 0278, 24 laboratories received a second set of samples. Of the 16 groups returning data, 4 had corrected their problems to the extent that at least 3 of their samples fell within ±15 percent of the EPA values.

Thirty-one laboratories received recheck samples for audit 0878. Nineteen of these groups returned data, of which 12 had corrected their problems to the point where at least 3 samples fell within ±15 percent of the EPA values.

From our compiled results, we concluded that a large percentage of the laboratories were having $SO_4^=$ analytical problems. The recheck samples indicated that the difficulties were real and that the poor performance was not due to chance.

Summary

The $SO_4^=$ audit start dates covered in this report are Febuary and August, 1978. The number of participants ranged from 73 to 84. Foreign, EPA, State, local, and private laboratories submitted data.

Five analytical methods were used with the majority of laboratories employing either the automated methylthymol blue, manual barium chloride, or manual Sulfa-ver methods.

Overall results showed no bias between the reported and EPA values and statistical distributions appeared to be normal. The automated methylthymol blue method exhibited the greatest accuracy and precision. The barium chloride and Sulfa-ver methods were approximately equal in accuracy. Average slopes (reported vs. EPA) for each audit ranged from 1.031 to 1.050 with intercept values from -0.383 to -0.324.

HI-VOL NITRATE

Participant Characteristics

Nitrate audit number 0278 began in February, 1978. Out of 49 laboratories returning sulfate data, all submitted nitrate results; two groups analyzed only nitrate. Audit 0878 began in August, 1978. Out of 58 sulfate results received, 47 returned nitrate data. Table 34 indicates the monitoring agency distribution.

Methods used to analyze the samples were grouped into 5 broad categories. Table 35 lists the analytical methods used and the number of respondents for each method.

TABLE 34. NO_3^- AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
NO_3^- audit - 0278						
Agencies requesting samples	2	1	23	12	13	51
Agencies returning data	2	1	23	12	13	51
NO_3^- audit - 0878						
Agencies requesting samples	2	2	21	9	13	47
Agencies returning data	2	2	21	9	13	47

TABLE 35. NO_3^- ANALYTICAL METHODS

Method	Agencies using method	
	Audit 0278	Audit 0787
Cadmium reduction - manual	4	4
Cadmium reduction - automated	23	22
Hydrazine reduction - manual	1	1
Hydrazine reduction - automated	6	7
Other	17	13

It should be noted that some agencies tend to define the analytical methods used in very general terms. A laboratory reporting the use of the automated cadmium reduction method may have used that method with various modifications. Thus, Table 35 should be interpreted as 23 laboratories in audit 0278 having used procedures approximating the automated cadmium reduction method.

Acceptable Ranges

As described in a previous section, two performance ranges were used as one means of judging performance. The Sample and Target ranges for NO_3 are listed in Table 36 and apply to concentrations in ascending order.

TABLE 36. NO_3^- SAMPLE AND TARGET RANGES (%)

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Sample range	± 5	± 5	± 5	± 5	± 5	± 5
Target range	±15	±15	±15	±15	±15	±15

Both ranges were arbitrarily set at the values listed in Table 36. As more audits are conducted and more data become available, the ranges will be refined.

For audit 0278, a total of 12 (24%) agencies reported 5 or 6 results within the Target ranges, while 2 (4%) laboratories reported all results outside these ranges. The corresponding figures for audit 0878 showed 24 (51%) and 7 (15%), respectively. Figure 16 shows a graph of the above values.

Data Summary

Any laboratory not reporting at least one value within the Target ranges would be considered an outlier and its data was not included in the summaries. Two laboratories met this criterion for outlier rejections in audit 9278, and 7 in 0878.

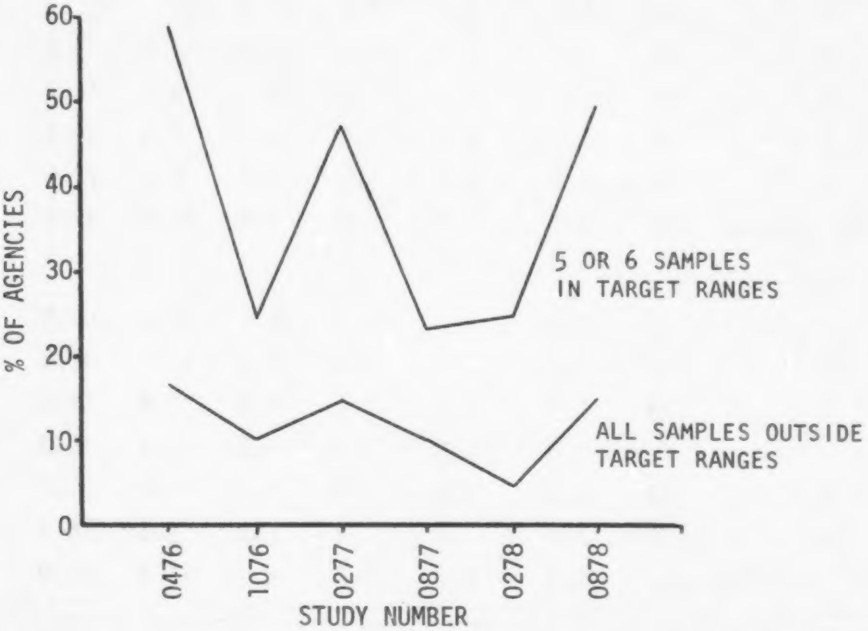

Figure 16. Plot of NO_3^- results (5 or 6 samples within and 6 samples outside Target ranges).

Table 37 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{absolute percent difference} = \left|\frac{\text{reported value - EPA value}}{\text{EPA value}}\right| \times 100.$$

The frequency distribution was then constructed and appears below. It should be noted that the "All samples" line is not an average of the numbers appearing above, but is the data examined together regardless of the concentration.

TABLE 37. NO_3^- ABSOLUTE PERCENT DIFFERENCE

Concentration	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
NO_3^- audit - 0278									
1				BLANK					
2	49	0.0	17.8	33.3	60.0	86.7	151.1	1766.7	141.0
3	48	0.0	0.7	4.2	13.2	18.8	39.6	650.0	43.1
4	48	0.0	0.2	1.9	5.7	9.7	16.4	43.0	7.9
5	49	0.0	0.5	1.7	3.6	7.4	20.4	72.7	8.8
6	48	0.1	0.4	1.9	4.2	8.3	22.5	89.9	11.8
All samples	242	0.0	0.8	2.9	8.0	20.0	77.8	1766.7	42.8
NO_3 audit - 0878									
1	40	0.0	1.4	8.3	18.1	38.9	62.5	166.7	30.7
2	40	0.0	0.0	4.4	8.3	14.4	32.8	490.6	24.1
3	38	0.0	0.0	2.1	4.2	6.0	15.0	43.8	7.1
4	40	0.0	0.8	2.5	6.7	7.2	16.0	36.7	7.6
5	39	0.2	0.6	1.9	3.8	5.8	16.8	38.5	6.7
6	39	0.0	1.0	2.1	6.0	9.6	18.4	108.8	11.0
All samples	236	0.0	0.6	2.7	6.1	11.1	31.9	490.6	14.6

Table 37 enables laboratories to determine their relative performance. For example, only 10% of the labs in audit 0278 reported results for concentration 3 that had a percent difference of 0.7 or less, while 50% of the laboratories reported a percent difference of 13.2 or less for the same concentration. The table also indicates the average percent difference for all laboratories for total samples. These values are illustrated in Figure 17 along with corresponding values from previous audits.

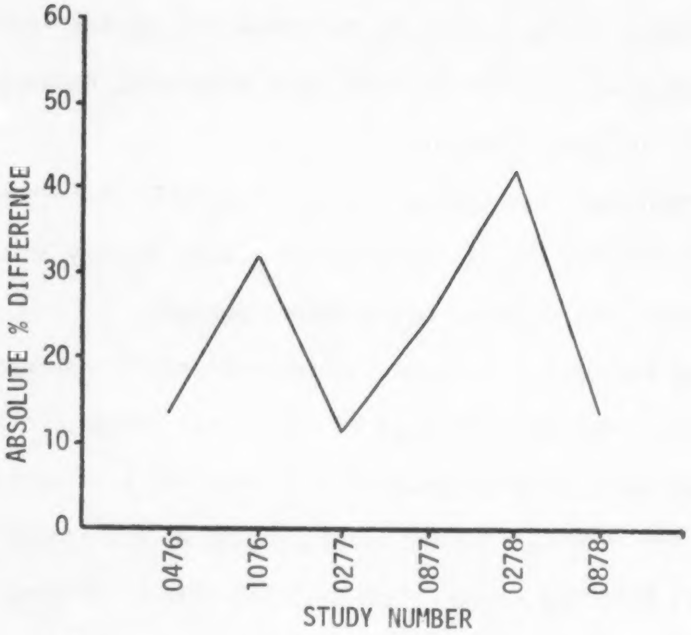

Figure 17. Plot of NO_3^- absolute percent differences.

Concentration 1 was a blank for audit 0278 and was excluded from the "All samples" distribution. Because small concentration differences result in large percent differences, it was felt that the numbers would unduly distort the study results. Attention should be given to the mean for 0278. The 42.8 percent value is inflated due to the low concentration of sample 2. If sample 2 is omitted, the mean is approximately 14 percent.

Results for each sample value are listed in the Appendix in increasing concentration. The summary statistics which appear in Table 38 and at the top of each listing in the Appendix do not include outliers. The "Outliers removed" column contains data on which an outlier test was applied. All data that met the second criterion described in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents, damaged samples, and inclusion of duplicate samples.

Table 38 indicates that the results were normally distributed (skewness near zero). Lower value samples appeared to cause accuracy problems. However, in general the accuracy was within 5 percent.

Each set of laboratory data was plotted against its corresponding EPA data set, and the slope and intercept of the linear regression line were determined. For audit 0278 the mean of 49 slopes was 1.047 with a standard deviation of 0.216; the mean intercept was -0.185 with a standard deviation of 2.409. Audit 0878 had a mean slope of 1.013 with a standard deviation of 0.159; the mean intercept was 0.008 with a standard deviation of 0.565. Figure 18 shows a plot of these results.

TABLE 38. NO_3^- SUMMARY STATISTICS ($\mu g/m^3$)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5		Concentration 6	
	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed
NO_3^- audit - 0278												
Number	28	27	49	47	48	46	48	46	49	47	48	45
True value	0.00	0.00	0.45	0.45	1.44	1.44	10.50	10.50	12.00	12.00	14.40	14.40
Mean	0.57	0.26	1.04	0.74	1.90	1.54	10.33	10.35	11.57	11.85	13.17	13.91
Median	0.24	0.21	0.72	0.69	1.50	1.50	10.40	10.40	11.81	11.83	14.21	14.25
Range	8.99	0.92	8.30	1.79	10.49	3.34	7.68	4.45	12.32	7.76	14.74	8.23
Std. dev.	1.66	0.21	1.51	0.11	1.82	0.45	1.22	0.94	1.89	1.27	3.27	1.56
Coef. var.	290.76	81.20	144.73	44.80	95.82	29.01	11.77	9.05	16.31	10.72	24.84	11.19
Skewness*	4.62	1.07	4.19	1.04	4.08	1.80	-0.63	-0.32	-1.97	-0.25	-2.51	-1.82
Accuracy+	-	-	60.00	53.33	4.17	4.17	-0.95	-0.95	-1.58	-1.42	-1.35	-1.04
NO_3^- audit - 0878												
Number	40	38	40	39	38	36	40	38	39	38	39	37
True value	0.72	0.72	1.80	1.80	4.80	4.80	6.00	6.00	9.60	9.60	11.40	11.40
Mean	0.88	0.83	2.09	1.87	4.66	4.76	5.80	5.90	9.30	9.39	11.61	11.09
Median	0.80	0.80	1.86	1.85	4.76	4.78	5.86	5.90	9.45	9.49	11.16	11.13
Range	1.65	1.00	9.53	1.70	2.87	1.80	3.16	2.26	5.31	3.97	14.62	4.92
Std. dev.	0.30	0.21	1.42	0.31	0.56	0.35	0.62	0.47	0.95	0.78	2.56	1.01
Coef. var.	34.18	25.44	67.74	16.56	11.97	7.41	10.69	7.95	10.23	8.30	22.00	9.11
Skewness*	1.32	-0.08	5.44	0.54	-1.69	0.03	-1.12	-0.24	-1.24	-0.45	3.30	0.49
Accuracy+	11.11	11.11	3.61	2.78	-0.83	-0.42	-2.25	-1.67	-1.56	-1.09	-2.11	-2.37

*A statistic indicating the lack of symmetry in a distribution. For a normal distribution this value is near zero.

$^+ \dfrac{\text{median - true value}}{\text{true value}} \times 100$

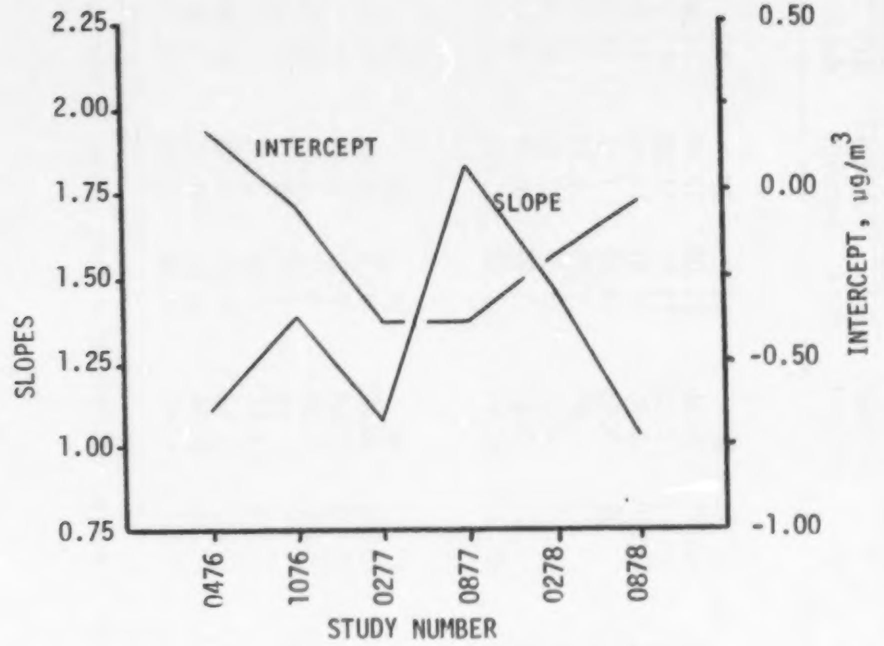

Figure 18. Plot of NO_3^- slope and intercept.

Analytical Method Summary

A check was made to determine whether any relationship existed between the laboratories that submitted data that was omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). Table 39 resulted from this check.

No particular method was determined responsible for most of the outlier values. (See Table 39). It is also obvious that, as yet, no one method is the "method of choice".

TABLE 39. SUMMARY OF NO_3^- ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total no. using method	No. identified as outliers	% of total as outliers
NO_3^- audit - 0278			
Cadmium reduction - manual	4	0	0
Cadmium reduction - automated	23	0	0
Hydrazine reduction - manual	1	1	100
Hydrazine reduction - automated	6	0	0
Other	17	1	6
NO_3^- audit - 0878			
Cadmium reduction - manual	4	0	0
Cadmium reduction - automated	22	3	14
Hydrazine reduction - manual	1	1	100
Hydrazine reduction - automated	7	1	14
Other	13	2	15

Table 40 contains the means and standard deviations of each sample concentration for each method used and is useful in determining whether a particular method yielded biased values.

Recheck Program

Starting with audit 0278, a recheck program was begun. A laboratory reporting at least 3 results greater than ±15 percent of the EPA values was sent a second set of samples. For audit 0278, 18 laboratories received a second set. Of the 5 groups returning data, 2 had corrected their problems to the extent that at least 3 samples fell within ±15 percent of the EPA values. Fourteen laboratories received recheck samples for audit 0878. Nine of these groups returned data, of which 5 had corrected their problems.

TABLE 40. MEAN AND STANDARD DEVIATION OF NO_3^- RESULTS BY ANALYTICAL GROUP

Method	Conc. 1		Conc. 2		Conc. 3		Conc. 4		Conc. 5		Conc. 6	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
NO_3^- audit - 0278												
Cad. red. - manual	2.25	4.50	3.60	4.12	3.98	4.56	10.60	1.42	13.16	1.72	15.20	0.87
Cad. red. - automated	0.14	0.18	0.72	0.39	1.82	1.76	10.42	1.52	11.48	1.41	12.86	3.71
Hyd. red. - automated	0.37	0.32	0.77	0.36	1.88	0.93	10.45	0.59	11.13	1.66	13.68	1.40
Other	0.10	0.15	0.78	0.27	1.48	0.25	10.09	0.87	11.46	2.48	12.89	3.47
True value	0.00		0.45		1.44		10.50		12.00		14.40	
NO_3^- audit - 0878												
Cad. red. - manual	0.72	0.27	1.84	0.58	4.72	0.41	5.38	1.06	8.29	1.66	13.93	6.66
Cad. red. - automated	0.86	0.30	2.33	2.04	4.71	0.34	5.84	0.38	9.43	0.67	11.34	1.94
Hyd. red. - automated	0.87	0.21	1.84	0.22	4.08	1.00	5.44	0.77	8.90	1.09	11.26	1.65
Other	0.97	0.36	1.92	0.17	4.90	0.40	6.09	0.60	9.69	0.75	11.42	1.02
True value	0.72		1.80		4.80		6.00		9.60		11.40	

Summary

The NO_3^- audit start dates covered in this report were February and August, 1978. The number of participants submitting data ranged from 47 to 51. Foreign, EPA, State, local, and private laboratories returned results.

Four analytical methods were used (plus a category, "Other"). A large percentage of the samples were analyzed by methods in the "Other" category.

The overall results showed, with the exception of very low concentrations, little bias between the reported and EPA values. The statistical distribution of the results appeared to be normal. The automated cadmium reduction method showed the best accuracy, while the automated hydrazine reduction procedure had the best precision.

Average slopes (reported vs. EPA) for each audit ranged from 1.01 to 1.05 with intercepts from -0.185 to 0.008.

HI-VOL LEAD

Participant Characteristics

Lead audit number 0178 began in January, 1978. Out of 85 sample sets requested by participants, 69 sets of data were returned for a response rate of 81 percent. Audit 0678 began in June, 1978. Out of 88 sample sets requested by participants, 67 sets of data were returned for a response rate of 76 percent. Table 41 indicates the monitoring agency distribution.

TABLE 41. PB AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
Pb audit - 0178						
Agencies requesting samples	0	5	42	30	8	85
Agencies returning data	0	2	37	25	5	69
Pb audit - 0678						
Agencies requesting samples	0	6	42	30	10	88
Agencies returning data	0	5	35	23	4	67

Methods used to analyze the samples were grouped into 4 broad categories. Results were received from laboratories using 2 methods listed in Table 42.

TABLE 42. PB ANALYTICAL METHODS

Method	Agencies using method	
	Audit 0178	Audit 0678
Atomic absorption	69	68
Other	0	1

It should be noted that some agencies tend to define the analytical methods used in very general terms. A laboratory reporting usage of the atomic absorption procedure as the method of choice may have used that procedure combined with modifications. Thus, Table 42 should be interpreted as 69 laboratories having used procedures during audit 0178 approximating the atomic absorption method.

A tabulation of the methods used to extract material from the filter is in Table 43.

TABLE 43. PB EXTRACTION PROCEDURES

Method	Agencies using method	
	Audit 0178	Audit 0678
Hot acid extraction	62	58
Cold acid extraction	3	3
Ultrasonication	1	3
Other	3	5

Acceptable Ranges

Sample and Target ranges are listed in Table 44 and apply to sample concentrations in ascending order. Both ranges were arbitrarily set at the values listed in Table 44. As more audits are conducted and more data become available, the ranges will be refined.

TABLE 44. PB SAMPLE AND TARGET RANGES (%)

	Conc. 1	Conc. 2	Conc. 3	Conc. 4	Conc. 5	Conc. 6
Sample range	± 5	± 5	± 5	± 5	± 5	± 5
Target range	±10	±10	±10	±10	±10	±10

For audit 0178, 29 agencies (51%) reported 5 or 6 samples within the Target ranges, while 7 laboratories (10%) reported results outside the Target ranges. The corresponding figures for audit 0678 showed 29 (43%) and 4 (6%), respectively.

Data Summary

Laboratories not reporting at least one value within the Target ranges were considered outliers and excluded from the summaries. Seven laboratories were rejected during audit 0178 and 4 during audit 0678; they were thus eliminated from further data summaries. The values identified as outliers are indicated in the Appendix by an asterisk (*).

Table 45 is a frequency distribution of the percent difference between the reported and EPA values for each sample concentration. The differences were calculated by the following formula:

$$\text{absolute percent difference} = \left|\frac{\text{reported value - EPA value}}{\text{EPA value}}\right| \times 100.$$

The frequency distribution was then constructed and appears below. It should be noted that the "All Samples" line is not an average of the number appearing above it, but is the distribution resulting when all data is examined together regardless of concentration.

TABLE 45. PB ABSOLUTE PERCENT DIFFERENCE

Concentration	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
Pb audit - 0178									
1				BLANK					
2	62	0.0	0.0	3.3	6.7	15.0	35.0	230.0	17.6
3	61	0.0	0.0	2.4	3.9	8.3	13.2	78.9	8.0
4	61	0.0	1.2	2.4	4.6	7.1	13.8	79.1	7.6
5	62	0.0	0.6	1.7	3.9	7.1	11.8	89.2	8.6
6	61	0.0	0.8	1.6	4.7	7.9	12.3	81.5	7.9
All samples	307	0.0	0.5	2.4	4.8	8.3	18.3	230.0	10.0
Pb audit - 0678									
1				BLANK					
2	62	0.0	0.0	2.4	4.8	11.9	31.0	969.0	27.7
3	62	0.0	0.7	3.3	5.3	8.0	15.3	68.0	8.7
4	62	0.0	0.6	1.8	4.2	6.1	12.5	79.2	7.1
5	63	0.0	0.3	2.2	4.2	8.4	24.3	81.0	10.6
6	63	0.0	0.0	2.8	5.0	7.0	15.9	79.8	8.4
All samples	312	0.0	0.4	2.8	4.8	8.0	20.9	969.0	12.5

Table 45 is useful to laboratories in determining their relative performance. For example, only 10% of the labs reporting results for concentration 4 during audit 0178 had a percent difference of 1.2 or less, while 50 % of the laboratories reported a percent difference of 4.6 or less for the same concentration. The table also indicates the average percent difference for all laboratories for total samples. These values are tabulated in Figure 19.

Concentration 1 was a blank and was excluded in the "All samples" distribution. Because small concentration differences result in large percent differences, it was felt that the numbers would unduly distort the study results.

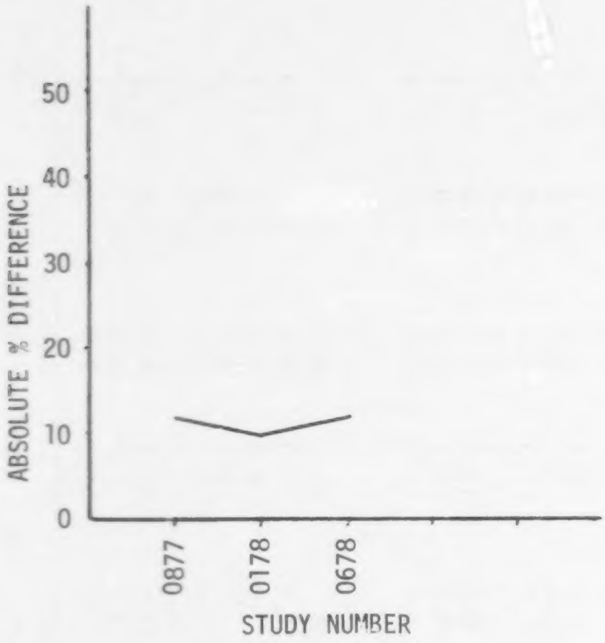

Figure 19. Plot of Pb absolute percent differences.

All data received (with the exception of the previously omitted data) were grouped according to concentration. The summary statistics which appear in Table 46 and at the top of each listing in the Appendix do not include outliers.

Table 46 lists summary statistics based on report data. The "Outliers removed" column contains data on which an outlier test has been applied. All data that met the second criterion mentioned in Section 3 were removed. It should be noted that the variation in the number of samples from concentration to concentration is due to laboratory accidents, damaged samples, and inclusion of duplicate samples.

TABLE 46. Pb SUMMARY STATISTICS ($\mu g/m^3$)

	Concentration 1		Concentration 2		Concentration 3		Concentration 4		Concentration 5		Concentration 6	
	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed	All data	Outliers removed
Pb audit - 0178												
Number	67	66	62	60	61	59	61	60	62	60	61	58
True value	0.00	0.00	0.6	0.6	2.0	2.0	6.6	6.6	10.2	10.2	12.6	12.6
Mean	0.30	0.05	0.6	0.6	2.0	2.0	6.4	6.5	9.7	10.0	11.9	12.1
Median	0.00	0.00	0.6	0.6	2.0	2.0	6.4	6.4	10.0	10.0	12.1	12.1
Range	1.20	0.40	1.8	0.8	2.0	0.9	7.3	3.6	13.4	8.8	14.8	5.3
Std. dev.	2.20	0.10	0.2	0.1	0.3	0.2	0.9	0.6	1.8	1.0	1.8	0.8
Coef. var.	733.30	200.00	35.6	20.1	15.8	8.0	13.7	9.1	18.6	10.0	14.9	6.7
Skewness*	3.12	1.60	3.5	-0.6	-3.2	-0.4	-2.7	0.7	-2.9	0.2	-2.7	-0.6
Accuracy+	-	-	0.0	0.0	0.0	0.0	-2.7	-2.5	-1.6	-1.4	-3.8	-3.7
Pb audit - 0678												
Number	69	68	66	65	66	64	66	63	67	65	67	64
True value	0.00	0.00	0.4	0.4	1.5	1.5	5.0	5.0	9.9	9.9	12.0	12.0
Mean	0.20	0.04	0.5	0.4	1.5	1.5	4.8	4.9	9.7	9.9	11.3	11.5
Median	0.00	0.00	0.4	0.4	1.5	1.5	4.9	4.9	9.9	9.9	11.6	11.6
Range	9.70	1.20	4.4	1.7	1.8	1.1	6.1	2.6	13.1	11.0	15.6	5.6
Std. dev.	1.20	0.30	0.5	0.2	0.2	0.2	0.8	0.4	2.1	1.6	2.1	1.2
Coef. var.	600.00	850.00	106.2	44.2	16.1	12.0	16.2	9.0	21.8	16.5	18.2	10.1
Skewness*	3.18	2.10	6.5	4.9	-0.6	-0.1	-2.0	-0.4	-1.3	0.0	-1.8	-0.8
Accuracy+	-	-	0.0	0.0	1.0	1.0	-1.8	-1.8	0.0	0.0	-3.0	-3.0

*A statistic indicating the lack of symmetry in a distribution. For a normal distribution this value is near zero.

+$\frac{\text{median - true value}}{\text{true value}} \times 100$

With the exception of concentration 1, the EPA determined "True value", and the mean and median of the study results agree well. This is indicated in the "accuracy" column. The greatest difference was approximately 3.7 percent. The relatively poor agreement between the EPA and reported values for concentration 1 is an indication of the minimum detectable limits of the analytical methods used.

Each data set was plotted against its corresponding EPA set, and the slope and intercept were determined. For audit 0178, the mean of 62 slopes was 1.120 with a standard deviation of 0.612; the mean intercept was -0.052 with a standard deviation of 0.409. The corresponding values for audit 0678 were a slope of 1.068 with a standard deviation of 0.534, and an intercept of 0.014 with a standard deviation of 0.468.

Analytical Method Summary

A check was made to determine whether any relationship existed between the five laboratories that submitted data that were omitted from the summaries and the analytical method employed (i.e., was any one method responsible for most of the data outliers). Table 47 resulted from this check.

As can be seen in Table 47, with the exception of one laboratory, all of the outlier labs used the atomic absorption method.

Recheck Program

Starting with audit 0178, a recheck program was begun. Any laboratory reporting at least 3 results greater than ±10 percent of the EPA values was sent a second set of samples. For audit 0178, 24 laboratories received a second set of samples. Of the 5 groups returning data, only 1 had corrected it problems to the extent that at least 3 samples fell within ±10 percent of the EPA values.

TABLE 47. SUMMARY OF PB ANALYTICAL METHODS USED BY OUTLIER LABS

Method	Total number using method	Number identified as outliers	% of total as oultiers
Pb audit - 0178			
Atomic absorption	69	7	10
Other	0	0	0
Pb audit - 0678			
Atomic absorption	68	4	6
Other	1	0	0

Twenty-five laboratories received recheck samples for audit 0678. Eleven of these groups returned data, of which 5 had corrected their problems to the extent that at least three samples fell within ±10 percent of the EPA values.

Summary

The Pb audit survey 0178 began in January, 1978. Eighty-five laboratories requested samples, of which 69 returned results for a response rate of 81 percent. Audit 0678 began in June, 1978. Eighty-eight laboratories requested samples, of which 67 returned results. EPA, State, local, and private laboratories submitted data. Two analytical methods were used. Ninety-nine percent of the laboratories used the atomic absorption procedure. One laboratory used the "Other" technique.

Overall agreement between reported and EPA values was good. No bias was evident, and the results were normally distributed. The average percent difference between the EPA results and reported results was 10.0 percent for audit 0178, and 12.5 percent for audit 0678. This figure does not include the blank data.

HI-VOL FLOW RATE

Participant Characteristics

Hi-vol flow rate audit number 0578 began in May, 1978. Out of 221 agencies requesting to participate, 162 responded with data, for a response rate of 73 percent. A total of 1,241 Hi-Vol units were tested.

Table 48 indicates the monitoring agency distribution. Methods used to measure the flow rate were grouped into 3 categories: rotameters, pressure transducers, and "other". Table 49 lists the measurement methods and the number of units employing the method.

TABLE 48. HI-VOL FLOW RATE AGENCY DISTRIBUTION

	Foreign	EPA	State	Local	Private	Total
Hi-vol audit 0578						
Agencies requesting ReF	4	9	69	127	12	221
Agencies returning data	4	5	54	94	5	162

TABLE 49. HI-VOL FLOW RATE MEASUREMENT METHODS

Method	Units using method Audit 0578
Rotameter	496
Pressure transducer	530
Other	215

Table 49 indicates that, compared to previous years, a trend is developing away from the rotameter to other more precise and accurate measurement methods.

Acceptable Ranges

Sample and Target ranges were calculated as ±5 and ±9 percent, respectively.

Using this criterion, a tabulation was made of the number of samplers reporting results within the ranges. A total of 744 samplers (60%) reported 4 or 5 readings within the Target ranges, while 144 units (12%) reported 4 or 5 readings outside the Target ranges. Fifty agencies accounted for 111 units reporting all values outside the Target ranges.

Data Summary

Table 50 is a frequency distribution of the percent difference between the reported and EPA values for each measurement pair. The differences were calculated using the following formula:

$$\text{percent difference} = \frac{\text{reported value - EPA value}}{\text{EPA value}} .$$

An iterative routine eliminated outliers while constructing the distribution. During each pass of the data, a check was performed to determine which reported values met the second criterion mentioned in Section 3. These values were removed, and the procedure repeated until no outliers were identified. This is the distribution that is titled "Outliers removed" in Table 50. A total of 8 passes were required to remove all outliers; 185 values were omitted.

TABLE 50. HI-VOL FLOW RATE PERCENT DIFFERENCES

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
Hi-vol audit - 0578									
All values	5983	-513	-12	-4	-1	2	6	100	-18
Outliers removed	5798	-24	-10	-4	-1	2	6	21	-1

Removal of the outliers had little effect on the main body of the Table.

Table 50 is useful when evaluating the overall audits. Excluding outliers, of all the observations reported for audit 0578, 80 percent were within ±10 percent of the EPA calculated value. The overall average difference was -1 percent.

A histogram was constructed of the total values (Figure 19) and reveals a slight negative bias (values less than EPA). The distributions appear normal, with slight negative skewing. However, considering the diversity of the measurement sources, the results appear well behaved and showed excellent precision.

All reported value pairs for each audit were summarized using linear regression equation:

$$y = mx + b \qquad (5)$$

where y = reported value

x = EPA value

The resulting equation for audit 0578 was:

$$y = 0.953\,x + 2.609 \qquad (6)$$

Because of the large intercept, the equation appears to indicate a larger bias than actually exists. Since equation 6 is valid only over the range

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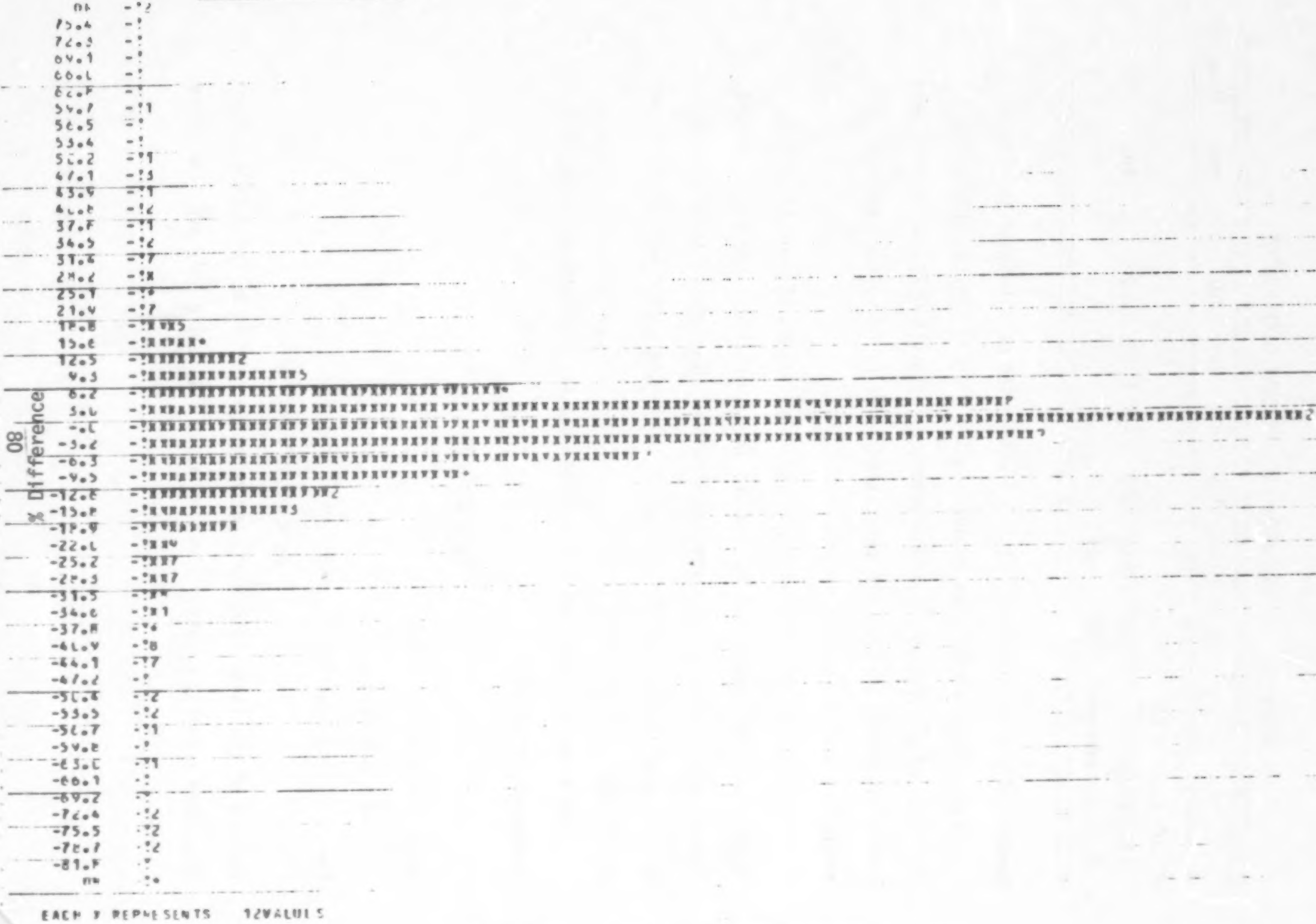

Figure 20. Hi-vol flow rate histogram - 1978

for which the test was conducted (30-60 ft^3/min), the influence of the intercept was not as great as indicated.

Measurement Method Summary

To determine whether a measurement method produced biased results and to gain an indication of its accuracy and precision, the numbers in Table 50 were separated by method, yielding Table 51.

TABLE 51. SUMMARY OF HI-VOL FLOW RATE MEASUREMENT METHODS

	No.	Min.	10%	30%	50%	70%	90%	Max.	Mean
Hi-vol audit - 0578									
Rotameter	2269	-30	-14	-6	-2	1	7	25	-2.6
Pressure Transducer	2515	-20	-8	-3	0	2	6	19	-0.6

The numbers generated in Table 51 are the result of several iterations similar to the "Outliers removed" values of Table 50.

It is obvious from Table 51 that the pressure transducer method is more accurate than the rotameter method. The table also supports the idea that the apparent bias revealed in Table 50 is largely due to the negative bias of the rotameter readings.

Forty-nine percent of the units using the rotameter were able to report 4 or 5 values within the Target ranges, while 65 percent of the units employing the pressure transducer reported 4 or 5 values within the Target ranges. Linear regression equations for each method were derived using equation 4 as described in the preceding sections. The resulting equations appear below:

Equations	Measurement Method	
$y = 0.945 + 3.413$	rotameter	(7)
$y = 0.960 + 1.907$	pressure transducer	(8)

Pressure transducer measurement pairs resulted in a slope closer to unity and an intercept closer to zero than did rotameter pairs.

Summary

The Hi-vol flow rate audit covered in this report started in May, 1978. The number of participants requesting an audit device was 221; 162 returned data for a response rate of 73 percent. A total of 1,241 samplers were checked. Foreign, EPA, State, local and private laboratories submitted data.

The results from both audits showed a slight bias between EPA and reported results with slightly skewed distribution patterns. Considering the number of units checked and the number of participating personnel, bias and skewing were assumed insignificant.

The slope of the equation representing all values was 0.953 with an intercept of 2.609.

SECTION 6

REFERENCES

1. Chauvenet, William. A Manual of Spherical and Practical Astronomy. J.B. Lippincott & Co., Philadelphia, Pennsylvania, 1863.

2. Code of Federal Regulations (40 CFR) 50.11, Appendix A, pp. 5.11.

3. Federal Register, Vol. 38, No. 110, June 8, 1973, pp. 15175-15176.

4. Bromberg, S., Bennett, B., and Lampe, R. Summary of Audit Performance Measurement of SO_2, NO_2, Sulfate, Nitrate - 1976. EPA 600/4-78-004, January, 1978.

APPENDIX

```
INTER-LABORATORY STUDY      878

POLLUTANT - SO4                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  0

N                  53         RANGE          17.10         C.I.(UPPER)  26.40
TRUE-VALUE      26.40         VARIANCE       10.55         C.I.(LOWE  R)  24.65
MEAN            25.52         STD. DEV.       3.25         SKEWNESS       -.44
MEDIAN          25.65         COEF. VAR.     12.73         ACCURACY      -2.84

DATA IN ASCENDING ORDER

         5.46 ●        22.80          25.40          26.32          28.00
        11.35 ●        23.10          25.44          26.40          28.77
        15.36          23.25          25.44          26.49          29.00
        15.60 ●        23.97          25.62          26.58          30.60
        18.90          24.39          25.65          26.70          30.60
        19.50          24.48          25.65          26.88          31.65
        20.40          24.75          25.70          27.30          32.00
        20.72          25.00          25.90          27.30          32.46
        21.12          25.20          25.93          27.40         100.36 ●
        21.48          25.20          26.10          27.60
        22.72          25.30          26.16          27.60
        22.80          25.35 —        26.28          27.89
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - SO4                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  52       RANGE           25.29        C.I.(UPPER)  39.88
TRUE-VALUE      39.60       VARIANCE        21.58        C.I.(LOWE  R)  37.35
MEAN            38.62       STD. DEV.        4.65        SKEWNESS       -.27
MEDIAN          38.36       COEF. VAR.      12.03        ACCURACY      -3.12

DATA IN ASCENDING ORDER

        8.54 ●          34.68           37.80           39.95           43.62
       18.92 ●          36.00           37.97           40.30           44.70
       21.15 ●          36.29           38.16           40.30           45.00
       24.96            36.30           38.18           40.50           45.00
       27.48            36.34           38.33           40.60           45.30
       31.10            36.36           38.40           41.34           47.72
       32.30            36.48           38.52           41.40           50.25
       33.00            36.60           39.00           42.00          154.79 ●
       34.05            37.20           39.36           42.20
       34.08            37.48           39.37           42.50
       34.13            37.53           39.72           43.20
       34.20            37.68           39.86           43.20
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - SO4                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 54          RANGE            8.37        C.I.(UPPER)  11.41
TRUE-VALUE     11.10          VARIANCE         2.62        C.I.(LOWE  R)  10.55
MEAN           10.98          STD. DEV.        1.62        SKEWNESS        -.36
MEDIAN         10.94          COEF. VAR.      14.73        ACCURACY       -1.40

DATA IN ASCENDING ORDER


        1.83 ●         10.01          10.59          11.33          12.50
        2.52 ●         10.05          10.62          11.39          12.60
        5.55 ●         10.05          10.80          11.50          12.80
        6.00           10.07          10.83          11.60          13.00
        7.41           10.08          10.85          11.70          13.50
        7.95           10.11          10.94          11.76          13.62
        8.22           10.14          10.95          11.79          13.88
        8.93           10.20          11.04          11.80          14.10
        9.30           10.35          11.10          11.94          14.37
        9.60           10.37          11.20          12.00          43.70 ●
        9.90           10.40          11.25          12.40
       10.00           10.44          11.27          12.48
```

```
INTER-LABORATORY STUDY      678

POLLUTANT - SO4                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 51        RANGE             8.76          C.I.(UPPER)  13.26
TRUE-VALUE     13.50        VARIANCE          3.93          C.I.(LOWE  R)  12.17
MEAN           12.71        STD. DEV.         1.98          SKEWNESS       -.69
MEDIAN         12.90        COEF. VAR.       15.60          ACCURACY      -4.44

DATA IN ASCENDING ORDER

      2.70 ●        11.60           12.80           13.40           14.59
      4.20 ●        11.82           12.80           13.50           14.84
      6.46 ●        11.94           12.83           13.50           15.80
      7.62          12.00           12.89           13.90           16.00
      8.00          12.25           12.90           13.95           16.26
      8.23          12.27           12.96           13.98           16.38
      9.10          12.30           13.01           14.00           53.92 ●
      9.12          12.34           13.14           14.04
     10.04          12.60           13.20           14.10
     10.05          12.60           13.24           14.25
     10.62          12.69           13.27           14.30
     10.71          12.70           13.38           14.50
```

```
INTER-LABORATORY STUDY      678

POLLUTANT - SO4                          UNITS  - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                  52         RANGE              8.15          C.I.(UPPER)    3.83
TRUE-VALUE       3.00         VARIANCE           1.70          C.I.(LOWE  R)    3.12
MEAN             3.47         STD. DEV.          1.31          SKEWNESS       1.88
MEDIAN           3.15         COEF. VAR.        37.60          ACCURACY       5.00

DATA IN ASCENDING ORDER


         .72 ●           2.63           3.03           3.62           4.95
        1.00             2.76           3.10           3.80           4.95
        1.20 ●           2.80           3.12           3.80           5.10
        1.50             2.81           3.12           3.90           5.25
        2.10             2.83           3.18           3.96           7.15
        2.29             2.88           3.20           4.00           9.15
        2.30             2.88           3.20           4.00          11.68 ●
        2.34             2.90           3.30           4.09
        2.40             2.91           3.38           4.20
        2.46             3.00           3.45           4.32
        2.50             3.00           3.45           4.50
        2.57             3.01           3.53           4.80
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - SO4                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  9

N                  44      RANGE              6.12        C.I.(UPPER)    2.48
TRUE-VALUE       1.30      VARIANCE           1.80        C.I.(LOWE  R)    1.68
MEAN             2.08      STD. DEV.          1.34        SKEWNESS       1.87
MEDIAN           1.68      COEF. VAR.        64.48        ACCURACY      29.23

DATA IN ASCENDING ORDER

        .24 ●         1.10          1.50          1.84          3.10
        .45 ●         1.19          1.53          1.90          3.48
        .69           1.29          1.56          2.00          3.83
        .77           1.30          1.60          2.10          3.90
        .83           1.32          1.68          2.40          5.10
        .84 ●         1.36          1.68          2.40          6.15
        .90           1.40          1.72          2.40          6.81
        .90           1.43          1.78          2.60          9.05 ●
        .91           1.44          1.80          2.70
        .98           1.45          1.80          2.88
```

```
INTER-LABORATORY STUDY      278

POLLUTANT - SO4                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  0

N                 43       RANGE             7.68          C.I.(UPPER)    3.28
TRUE-VALUE      2.70       VARIANCE          1.52          C.I.(LOWE  R)    2.55
MEAN            2.91       STD. DEV.         1.23          SKEWNESS       1.46
MEDIAN          2.90       COEF. VAR.       42.25          ACCURACY       7.41

DATA IN ASCENDING ORDER

        .18             2.10             2.78             3.00             3.90
        .49 ●           2.29             2.79             3.00             4.00
        .69             2.37             2.80             3.00             4.20
       1.36             2.37             2.81             3.04             4.69
       1.50 ●           2.42             2.90             3.12             5.92
       1.50 ●           2.51             2.90             3.16             6.60 ●
       1.73             2.57             2.90             3.20             7.80 ●
       1.74             2.59             2.91             3.40             7.86
       1.91             2.62             2.93             3.45            13.80 ●
       1.96             2.70             2.94             3.60
```

```
INTER-LABORATORY STUDY      278

POLLUTANT - SO4                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  41        RANGE           11.01          C.I.(UPPER)    2.77
TRUE-VALUE       1.80        VARIANCE         2.81          C.I.(LOWE  R)    1.75
MEAN             2.26        STD. DEV.        1.68          SKEWNESS        3.66
MEDIAN           1.98        COEF. VAR.      74.16          ACCURACY       10.00

DATA IN ASCENDING ORDER


       .18              1.45              1.89              2.32              3.75
       .24              1.59              1.98              2.40              4.50 ●
       .60 ●            1.60              1.98              2.52              4.61
       .90              1.70              2.00              2.58              7.15 ●
       .98              1.72              2.01              2.60             10.20 ●
       .99              1.79              2.03              2.70             11.19
      1.20 ●            1.80              2.10              2.84
      1.25              1.82              2.10              3.22
      1.34              1.87              2.11              3.40
      1.40              1.88              2.13              3.70
```

```
INTER-LABORATORY STUDY      278

POLLUTANT - SO4                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 43        RANGE          11.12        C.I.(UPPER)    9.81
TRUE-VALUE      9.60        VARIANCE        4.00        C.I.(LOWE  R)    8.62
MEAN            9.22        STD. DEV.       2.00        SKEWNESS      -2.86
MEDIAN          9.59        COEF. VAR.     21.72        ACCURACY       -.10

DATA IN ASCENDING ORDER


        .48            8.69            9.41            9.80           10.80
       2.10            8.83            9.50            9.80           10.90
       7.20 ●          8.92            9.58            9.95           11.16
       7.35            9.00            9.59           10.05           11.49
       7.68            9.05            9.60           10.05           11.60
       8.10 ●          9.14            9.60           10.08           12.00 ●
       8.20            9.18            9.64           10.50           12.54 ●
       8.50            9.23            9.70           10.58           15.60 ●
       8.55            9.30            9.72           10.63
       8.67            9.30            9.72           10.65
```

```
INTER-LABORATORY STUDY      278

POLLUTANT - S04                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 44          RANGE           14.05          C.I.(UPPER)  12.20
TRUE-VALUE     12.00          VARIANCE         4.67          C.I.(LOWE  R)  10.92
MEAN           11.56          STD. DEV.        2.15          SKEWNESS      -2.92
MEDIAN         11.88          COEF. VAR.      18.70          ACCURACY       -.96

 DATA IN ASCENDING ORDER


        .61            11.07            11.70            12.04            13.44
       8.15            11.11            11.72            12.06            13.56
       8.64            11.18            11.77            12.10            13.80
       8.85            11.20            11.88            12.14            13.85
       9.30 ●          11.20            11.89            12.20            14.31 ●
       9.60 ●          11.35            11.89            12.30            14.60
       9.75            11.51            11.96            12.60            14.67
      10.56            11.55            12.00            12.87            15.30 ●
      10.56            11.62            12.00            12.98
      10.98            11.70            12.00            13.08
```

```
INTER-LABORATORY STUDY      278

POLLUTANT - SO4                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  44      RANGE          17.52        C.I.(UPPER)  14.68
TRUE-VALUE      14.40      VARIANCE        6.67        C.I.(LOWE  R)  13.16
MEAN            13.92      STD. DEV.       2.58        SKEWNESS     -2.87
MEDIAN          14.02      COEF. VAR.     18.55        ACCURACY     -2.60

DATA IN ASCENDING ORDER

      .75          12.98          13.89          14.40          15.88
     8.93          13.23          13.93          14.40          16.02
     9.60 ●        13.24          13.94          14.40          16.25
    11.00 ●        13.40          14.00          14.46          16.95 ●
    12.15          13.45          14.05          14.76          17.27 ●
    12.35          13.47          14.20          15.10          17.28
    12.76          13.49          14.23          15.30          18.00 ●
    12.90          13.50          14.25          15.40          18.22
    12.94          13.76          14.35          15.49          18.27
    12.96          13.76          14.36          15.60
```

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INTER-LABORATORY STUDY      278

POLLUTANT - SO4                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  6

N                  29        RANGE            6.59         C.I.(UPPER)    1.83
TRUE-VALUE        .00        VARIANCE         2.41         C.I.(LOWER)     .70
MEAN             1.26        STD. DEV.        1.55         SKEWNESS       1.90
MEDIAN            .51        COEF. VAR.     122.91         ACCURACY        .00

DATA IN ASCENDING ORDER

        .01             .40             .51            1.45             4.44 ●
        .12             .43             .51            1.50 ●           4.50 ●
        .12             .48             .55            1.50             4.61
        .15             .48             .90            2.29             6.60
        .25             .49            1.09            2.30            10.80 ●
        .28             .50            1.25            2.96
        .36             .50            1.40            4.11
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - NO3                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                    40        RANGE             1.65        C.I.(UPPER)      .97
TRUE-VALUE          .72        VARIANCE           .09        C.I.(LOWE  R)     .78
MEAN                .88        STD. DEV.          .30        SKEWNESS        1.32
MEDIAN              .80        COEF. VAR.       34.18        ACCURACY       11.11

DATA IN ASCENDING ORDER

        .18 ●          .70            .78            .93           1.22
        .18 ●          .70            .78            .95           1.27
        .20 ●          .71            .80           1.00           1.30 ●
        .27            .71            .80           1.02           1.70
        .29 ●          .71            .80           1.06           1.92
        .50            .72            .80           1.06           2.60 ●
        .51            .74            .84           1.08
        .52            .75            .85           1.08
        .64            .75            .85           1.10
        .65            .77            .89           1.12
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - NO3                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  0

N                  39          RANGE           14.62          C.I.(UPPER)  12.42
TRUE-VALUE      11.40          VARIANCE         6.53          C.I.(LOWE  R)  10.81
MEAN            11.61          STD. DEV.        2.56          SKEWNESS       3.30
MEDIAN          11.16          COEF. VAR.      22.00          ACCURACY      -2.11

DATA IN ASCENDING ORDER

          2.48 ●          9.98          10.78          11.50          12.67
          2.55 ●          9.99          11.10          11.51          13.07
          2.55 ●         10.04          11.10          11.55          14.10
          2.78 ●         10.30          11.13          11.57          18.87
          5.16 ●         10.44          11.13          11.60          23.80
          5.90 ●         10.62          11.16          11.63          35.98 ●
          9.18           10.63          11.16          11.74
          9.30           10.70          11.19          11.80
          9.41           10.70          11.22          12.10
          9.90           10.71          11.40          12.18
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - NO3                            UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                   39          RANGE              5.31          C.I.(UPPER)    9.60
TRUE-VALUE        9.60          VARIANCE            .91          C.I.(LOWE  R)    9.01
MEAN              9.30          STD. DEV.           .95          SKEWNESS      -1.24
MEDIAN            9.45          COEF. VAR.        10.23          ACCURACY      -1.56

DATA IN ASCENDING ORDER


        2.11 ●            8.46             9.30             9.66             10.10
        2.19 ●            8.60             9.30             9.66             10.10
        2.22 ●            8.67             9.36             9.71             10.60
        2.32 ●            8.71             9.42             9.71             10.80
        3.24 ●            8.88             9.44             9.78             11.21
        4.10 ●            9.04             9.45             9.79             29.42 ●
        5.90              9.06             9.54             9.80
        7.24              9.09             9.55             9.84
        7.80              9.10             9.62             9.97
        7.83              9.13             9.66            10.00
```

```
INTER-LABORATORY STUDY      878

POLLUTANT - NO3                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                  40        RANGE            3.16          C.I.(UPPER)    5.99
TRUE-VALUE       6.00        VARIANCE          .38          C.I.(LOWE  R)    5.61
MEAN             5.80        STD. DEV.         .62          SKEWNESS      -1.12
MEDIAN           5.86        COEF. VAR.      10.69          ACCURACY      -2.25

DATA IN ASCENDING ORDER


        1.32 ●          5.05            5.66            5.99            6.40
        1.32 ●          5.40            5.74            6.00            6.43
        1.38 ●          5.43            5.76            6.06            6.43
        1.39 ●          5.55            5.77            6.06            6.46
        1.44 ●          5.57            5.85            6.10            6.61
        3.80            5.57            5.85            6.12            6.96
        4.10 ●          5.58            5.88            6.30           17.72 ●
        4.21            5.58            5.92            6.36
        4.70            5.60            5.95            6.38
        4.97            5.60            5.96            6.40
```

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INTER-LABORATORY STUDY      878

POLLUTANT - NO3                         UNITS - MICROGRAMS PER CUPIC METER

SAMPLE NUMBER -  5

N                   38          RANGE             2.87           C.I.(UPPER)    4.84
TRUE-VALUE        4.80          VARIANCE           .31           C.I.(LOWE  R)    4.4
MEAN              4.66          STD. DEV.          .56           SKEWNESS      -1.69
MEDIAN            4.76          COEF. VAR.       11.97           ACCURACY        -.83

DATA IN ASCENDING ORDER


        .20 ●           4.44             4.66             4.80             5.07
        .54 ●           4.50             4.66             4.81             5.20
       1.13 ●           4.51             4.67             4.81             5.20
       2.70             4.53             4.70             4.90             5.43
       2.95             4.53             4.75             4.90             5.52
       3.12 ●           4.54             4.77             4.90             5.57
       3.77             4.58             4.79             4.91            14.92 ●
       4.20             4.60             4.80             4.92
       4.25             4.60             4.80             4.92
```

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INTER-LABORATORY STUDY      678

POLLUTANT - NO3                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  9

N               40       RANGE           9.53        C.I.(UPPER)    2.53
TRUE-VALUE    1.80       VARIANCE        2.01        C.I.(LOWE  R)    1.65
MEAN          2.09       STD. DEV.       1.42        SKEWNESS       5.44
MEDIAN        1.86       COEF. VAR.     67.74        ACCURACY       3.61

DATA IN ASCENDING ORDER

        .41 ●        1.58          1.80          1.91          2.13
        .41 ●        1.60          1.80          1.91          2.16
        .42 ●        1.65          1.80          1.97          2.39
        .63 ●        1.65          1.82          2.00          2.47 ●
       1.00 ●        1.65          1.83          2.02          2.64
       1.09 ●        1.72          1.85          2.02          2.80
       1.10          1.73          1.88          2.06         10.63
       1.30          1.75          1.90          2.07
       1.50          1.80          1.90          2.07
       1.55          1.80          1.91          2.08
```

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INTER-LABORATORY STUDY      278

POLLUTANT - NO3                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  0

N                  49          RANGE           8.30        C.I.(UPPER)   1.46
TRUE-VALUE        .45          VARIANCE        2.27        C.I.(LOWE  R)     .62
MEAN             1.04          STD. DEV.       1.51        SKEWNESS       4.19
MEDIAN            .72          COEF. VAR.    144.73        ACCURACY      60.00

DATA IN ASCENDING ORDER

        .10            .55            .69            .84          1.32
        .18            .56            .69            .86          1.49
        .21            .56            .72            .87          1.52
        .36            .60            .72            .88          1.89
        .37            .60            .72            .90          4.34
        .43            .60            .76           1.00          7.80
        .45            .63            .78           1.03          8.40
        .50            .63            .80           1.03
        .53            .66            .81           1.08
        .53            .67            .81           1.08
        .54            .68            .81           1.13
```

```
INTER-LABORATORY STUDY      278

POLLUTANT - NO3
                                    UNITS - MICROGRAMS PER CUBIC METER
SAMPLE NUMBER -  2

N                  48
TRUE-VALUE       1.44        RANGE            10.49        C.I.(UPPER)   2.42
MEAN             1.90        VARIANCE          3.32        C.I.(LOWE  R)   1.39
MEDIAN           1.50        STD. DEV.         1.82        SKEWNESS        4.08
                             COEF. VAR.       95.82        ACCURACY        4.17
DATA IN ASCENDING ORDER


        .31            1.35            1.45            1.59            1.83
        .84            1.40            1.46            1.63            1.86
        .90            1.40            1.47            1.64            1.90
        .93            1.40            1.50            1.65            1.94
        .97            1.40            1.50            1.68            2.01
       1.20            1.40            1.50            1.70            2.10
       1.23            1.42            1.50            1.70            3.65
       1.25            1.43            1.51            1.71            9.75
       1.30            1.44            1.53            1.77           10.80
       1.34            1.44            1.58            1.80
```

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INTER-LABORATORY STUDY      278

POLLUTANT - NO3                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 48        RANGE          14.74          C.I.(UPPER)  14.09
TRUE-VALUE     14.40        VARIANCE       10.70          C.I.(LOWE  R)  12.24
MEAN           13.17        STD. DEV.       3.27          SKEWNESS      -2.51
MEDIAN         14.21        COEF. VAR.     24.84          ACCURACY      -1.35

DATA IN ASCENDING ORDER

        1.46            13.08            13.82            14.41            14.87
        1.52            13.13            14.00            14.44            14.88
        3.22            13.18            14.12            14.44            15.04
        6.30            13.25            14.16            14.50            15.11
        7.97            13.48            14.20            14.61            15.15
        9.42            13.68            14.21            14.64            15.60
       11.16            13.72            14.25            14.70            15.83
       11.16            13.80            14.28            14.73            16.00
       11.82            13.80            14.30            14.74            16.20
       12.99            13.82            14.35            14.81
```

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INTER-LABORATORY STUDY      278

POLLUTANT - NO3                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 48        RANGE            7.68        C.I.(UPPER)  10.67
TRUE-VALUE     10.50        VARIANCE         1.45        C.I.(LOWE  R)   9.98
MEAN           10.33        STD. DEV.        1.22        SKEWNESS        -.63
MEDIAN         10.40        COEF. VAR.      11.77        ACCURACY        -.95

DATA IN ASCENDING ORDER


       5.40             9.72            10.26            10.56            11.27
       5.98             9.82            10.30            10.59            11.30
       7.77             9.83            10.37            10.60            11.55
       8.56             9.86            10.39            10.61            11.70
       8.61             9.89            10.40            10.67            11.70
       8.97             9.90            10.40            10.76            11.93
       9.03             9.92            10.48            10.82            12.00
       9.18            10.02            10.50            11.00            12.22
       9.41            10.20            10.50            11.06            13.66
       9.48            10.24            10.50            11.16
```

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INTER-LABORATORY STUDY      278

POLLUTANT - NO3                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  49        RANGE           12.32         C.I.(UPPER)  12.10
TRUE-VALUE      12.00        VARIANCE         3.56         C.I.(LOWE  R)  11.04
MEAN            11.57        STD. DEV.        1.89         SKEWNESS     -1.97
MEDIAN          11.81        COEF. VAR.      16.31         ACCURACY     -1.58

DATA IN ASCENDING ORDER

        3.28          11.40          11.76          12.10          12.89
        5.58 ●        11.44          11.79          12.13          13.02
        6.65          11.49          11.80          12.15          13.12
        7.84          11.50          11.81          12.17          14.28
        8.79          11.56          11.83          12.18          14.45
        9.83          11.65          11.90          12.22          15.60
        9.97          11.70          11.94          12.43          19.68 ●
       10.07          11.70          11.94          12.48
       10.63          11.70          11.95          12.54
       11.00          11.72          11.98          12.77
       11.11          11.73          12.00          12.80
```

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INTER-LABORATORY STUDY      278

POLLUTANT - NO3                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  6

N                 28         RANGE            8.99        C.I.(UPPER)    1.19
TRUE-VALUE       .00         VARIANCE         2.77        C.I.(LOWE  R)    -.04
MEAN             .57         STD. DEV.        1.66        SKEWNESS       4.62
MEDIAN           .24         COEF. VAR.     290.76        ACCURACY        .00

DATA IN ASCENDING ORDER

        .01             .09             .20             .36             .50
        .03             .09             .21             .40             .56
        .03             .11             .28             .40             .93
        .03             .13             .28             .40            1.44
        .04             .19             .30             .41            9.00
        .05             .20             .34             .46
```

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INTER-LABORATORY STUDY      678

POLLUTANT - NO2                           UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                   82        RANGE             .15         C.I.(UPPER)      .13
TRUE-VALUE         .13        VARIANCE          .00         C.I.(LOWE  R)    .13
MEAN               .13        STD. DEV.         .02         SKEWNESS        3.55
MEDIAN             .13        COEF. VAR.      14.10         ACCURACY        2.38

DATA IN ASCENDING ORDER

        .09 ●          .12            .13            .13            .14
        .10            .12            .13            .13            .14
        .10            .12            .13            .13            .14
        .10            .12            .13            .13            .15
        .11            .12            .13            .13            .15
        .11            .12            .13            .13            .15
        .11            .12            .13            .13            .15
        .11            .12            .13            .13            .15
        .11            .12            .13            .14            .17
        .11            .12            .13            .14            .18
        .11            .12            .13            .14            .24 ●
        .12            .12            .13            .14            .25
        .12            .13            .13            .14            .60 ●
        .12            .13            .13            .14           6.45 ●
        .12            .13            .13            .14
        .12            .13            .13            .14
        .12            .13            .13            .14
        .12            .13            .13            .14
```

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INTER-LABORATORY STUDY      678

POLLUTANT - NO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  84        RANGE              .18         C.I.(UPPER)      .26
TRUE-VALUE        .24        VARIANCE           .00         C.I.(LOWE  R)      .25
MEAN              .25        STD. DEV.          .02         SKEWNESS        1.58
MEDIAN            .25        COEF. VAR.        8.90         ACCURACY        5.04

DATA IN ASCENDING ORDER


       .18 ●          .24            .25            .25            .26
       .19            .24            .25            .25            .27
       .20            .24            .25            .25            .27
       .21            .24            .25            .25            .27
       .22            .24            .25            .26            .27
       .22            .24            .25            .26            .27
       .22            .24            .25            .26            .28
       .22            .24            .25            .26            .28
       .22            .24            .25            .26            .28
       .22            .24            .25            .26            .28
       .23            .24            .25            .26            .30 ●
       .23            .24            .25            .26            .30
       .23            .25            .25            .26            .30
       .24            .25            .25            .26            .37
       .24            .25            .25            .26            .41 ●
       .24            .25            .25            .26          12.09 ●
       .24            .25            .25            .26
       .24            .25            .25            .26
```

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INTER-LABORATORY STUDY      678

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 84          RANGE             .16          C.I.(UPPER)     .26
TRUE-VALUE       .24          VARIANCE          .00          C.I.(LOWE  R)     .25
MEAN             .25          STD. DEV.         .02          SKEWNESS       1.96
MEDIAN           .25          COEF. VAR.       8.61          ACCURACY       4.58

DATA IN ASCENDING ORDER

          .18 ●          .24            .25            .25            .27
          .21            .24            .25            .26            .27
          .21            .24            .25            .26            .27
          .22            .24            .25            .26            .27
          .22            .24            .25            .26            .27
          .22            .24            .25            .26            .27
          .22            .24            .25            .26            .27
          .22            .24            .25            .26            .28
          .23            .25            .25            .26            .28
          .23            .25            .25            .26            .29
          .23            .25            .25            .26            .30
          .23            .25            .25            .26            .30
          .24            .25            .25            .26            .33 ●
          .24            .25            .25            .26            .37
          .24            .25            .25            .26            .43 ●
          .24            .25            .25            .26           1.73 ●
          .24            .25            .25            .27          11.99 ●
          .24            .25            .25            .27
```

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INTER-LABORATORY STUDY      678

POLLUTANT - NO2                      UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                  83         RANGE             .18          C.I.(UPPER)     .40
TRUE-VALUE        .37         VARIANCE          .00          C.I.(LOWE  R)     .38
MEAN              .39         STD. DEV.         .02          SKEWNESS       1.28
MEDIAN            .39         COEF. VAR.       6.28          ACCURACY       4.02

DATA IN ASCENDING ORDER


        .27 ●            .38              .39              .39              .41
        .32              .38              .39              .40              .41
        .35              .38              .39              .40              .41
        .35              .38              .39              .40              .41
        .35              .38              .39              .40              .41
        .36              .38              .39              .40              .41
        .36              .38              .39              .40              .42
        .36              .38              .39              .40              .42
        .36              .38              .39              .40              .42
        .36              .38              .39              .40              .43
        .36              .38              .39              .40              .48
        .36              .38              .39              .40              .50
        .36              .38              .39              .40              .52●
        .37              .38              .39              .40              .54●
        .37              .39              .39              .40              .54●
        .38              .39              .39              .41             1.00●
        .38              .39              .39              .41            18.66●
        .38              .39              .39              .41
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INTER-LABORATORY STUDY      678

POLLUTANT - NO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  82       RANGE               .43       C.I.(UPPER)    .72
TRUE-VALUE        .69       VARIANCE            .00       C.I.(LOWE  R)    .69
MEAN              .71       STD. DEV.           .05       SKEWNESS     -3.34
MEDIAN            .71       COEF. VAR.         7.03       ACCURACY      3.05

DATA IN ASCENDING ORDER

        .12 ●         .69           .70           .72           .74
        .12 ●         .69           .71           .72           .74
        .39           .69           .71           .72           .74
        .49 ●         .69           .71           .72           .74
        .55           .69           .71           .72           .75
        .63           .69           .71           .72           .75
        .64           .69           .71           .72           .75
        .66           .70           .71           .72           .76
        .67           .70           .71           .72           .77
        .67           .70           .71           .72           .77
        .67           .70           .71           .73           .77
        .67           .70           .71           .73           .78
        .68           .70           .71           .73           .82
        .68           .70           .71           .73           .84 ●
        .68           .70           .72           .73           .97 ●
        .68           .70           .72           .73         34.13 ●
        .68           .70           .72           .73
        .68           .70           .72           .73
```

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INTER-LABORATORY STUDY     1278

POLLUTANT - NO2                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                   74         RANGE              .13         C.I.(UPPER)      .28
TRUE-VALUE         .26         VARIANCE           .00         C.I.(LOWE  R)      .27
MEAN               .27         STD. DEV.          .03         SKEWNESS          .73
MEDIAN             .27         COEF. VAR.        9.21         ACCURACY         2.65

DATA IN ASCENDING ORDER


        .23             .25             .27             .28             .29
        .23             .25             .27             .28             .30
        .23             .25             .27             .28             .30
        .23             .25             .27             .28             .30
        .23             .26             .27             .28             .31
        .24             .26             .27             .28             .31
        .24             .26             .27             .29             .32
        .24             .26             .27             .29             .33
        .24             .26             .27             .29             .34
        .24             .26             .27             .29             .36
        .25             .26             .27             .29             .38 ●
        .25             .26             .28             .29             .59 ●
        .25             .26             .28             .29             .74 ●
        .25             .27             .28             .29           10.88 ●
        .25             .27             .28             .29
        .25             .27             .28             .29
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INTER-LABORATORY STUDY     1278

POLLUTANT - NO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                   74        RANGE              .13        C.I.(UPPER)     .40
TRUE-VALUE         .39        VARIANCE           .00        C.I.(LOWE  R)     .39
MEAN               .39        STD. DEV.          .03        SKEWNESS        .01
MEDIAN             .39        COEF. VAR.        6.62        ACCURACY        .52

DATA IN ASCENDING ORDER


         .33            .38            .39            .40            .42
         .34            .38            .39            .40            .43
         .34            .38            .39            .40            .43
         .34            .38            .39            .41            .43
         .34            .38            .39            .41            .43
         .35            .38            .39            .41            .43
         .36            .38            .39            .41            .43
         .36            .38            .39            .41            .43
         .36            .38            .39            .41            .45
         .37            .38            .39            .41            .46
         .37            .38            .39            .41            .56 ●
         .37            .38            .40            .41            .80 ●
         .37            .39            .40            .41            .88 ●
         .37            .39            .40            .41          15.90 ●
         .37            .39            .40            .41
         .37            .39            .40            .42
```

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INTER-LABORATORY STUDY     1278

POLLUTANT - NO2
                                   UNITS - MICROGRAMS PER CUBIC METER
SAMPLE NUMBER -  3

N                     71
TRUE-VALUE           .52        RANGE                 .22         C.I.(UPPER)      .53
MEAN                 .52        VARIANCE              .00         C.I.(LOWE  R)     .51
MEDIAN               .52        STD. DEV.             .04         SKEWNESS        -.63
                                COEF. VAR.           7.57         ACCURACY         .78
DATA IN ASCENDING ORDER

        .39           .50           .52           .53           .56
        .41           .50           .52           .54           .58
        .41           .50           .52           .54           .58
        .46           .50           .52           .54           .58
        .46           .50           .52           .54           .59
        .47           .51           .52           .54           .59
        .47           .51           .52           .54           .61
        .47           .51           .52           .54           .72 ●
        .48           .51           .52           .54           .89 ●
        .49           .51           .53           .55           .97 ●
        .49           .51           .53           .55         20.91 ●
        .49           .51           .53           .55
        .49           .52           .53           .55
        .49           .52           .53           .55
        .49           .52           .53           .55
        .50           .52           .53           .55
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INTER-LABORATORY STUDY     1278

POLLUTANT - NO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                   74        RANGE              .26        C.I.(UPPER)      .71
TRUE-VALUE         .70        VARIANCE           .00        C.I.(LOWE  R)      .70
MEAN               .71        STD. DEV.          .04        SKEWNESS         .61
MEDIAN             .70        COEF. VAR.        5.83        ACCURACY        -.00

DATA IN ASCENDING ORDER


          .58            .68            .70            .71            .74
          .63            .68            .70            .72            .74
          .63            .68            .70            .72            .74
          .65            .69            .70            .72            .76
          .65            .69            .70            .72            .77
          .65            .69            .70            .72            .78
          .67            .69            .70            .72            .80
          .67            .69            .70            .72            .81
          .67            .69            .70            .72            .82
          .67            .69            .71            .72            .84
          .67            .69            .71            .73           1.03 ●
          .68            .69            .71            .73           1.14 ●
          .68            .69            .71            .73           1.29 ●
          .68            .69            .71            .73          28.03 ●
          .68            .69            .71            .73
          .68            .69            .71            .73
```

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INTER-LABORATORY STUDY     1278

POLLUTANT - NO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 73          RANGE              .74        C.I.(UPPER)      .96
TRUE-VALUE       .93          VARIANCE           .01        C.I.(LOWE  R)      .92
MEAN             .94          STD. DEV.          .08        SKEWNESS       -2.75
MEDIAN           .94          COEF. VAR.        8.38        ACCURACY         .97

DATA IN ASCENDING ORDER


       .45           .92           .94           .96          1.00
       .80           .92           .94           .96          1.00
       .83           .92           .94           .96          1.00
       .85           .92           .94           .96          1.03
       .87           .92           .94           .96          1.03
       .88           .92           .94           .96          1.04
       .89           .92           .94           .96          1.04
       .89           .92           .95           .97          1.07
       .90           .92           .95           .97          1.19
       .90           .92           .95           .97          1.34 ●
       .90           .93           .95           .97          1.40 ●
       .90           .93           .95           .97          1.68 ●
       .91           .93           .95           .97         37.23 ●
       .91           .93           .95           .98
       .91           .93           .95           .98
       .91           .93           .96           .99
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INTER-LABORATORY STUDY      378

POLLUTANT - CO                   UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N               342      RANGE          42.90      C.I.(UPPER)     7.28
TRUE-VALUE     7.15      VARIANCE        5.25      C.I.(LOWE  R)    6.80
MEAN           7.04      STD. DEV.       2.29      SKEWNESS       15.36
MEDIAN         7.00      COEF. VAR.     32.54      ACCURACY       -2.10

DATA IN ASCENDING ORDER

    .21● 6.26      6.50  6.80      6.90  7.00      7.00  7.28      7.50   8.00
   4.00  6.30      6.50  6.80      6.90  7.00      7.00  7.28      7.50   8.00
   4.30  6.30      6.50  6.80      6.90  7.00      7.00  7.30      7.50   8.00
   4.40  6.30      6.50  6.80      6.90  7.00      7.00  7.30      7.50   8.05
   4.50  6.30      6.50  6.80      6.90  7.00      7.00  7.30      7.50   8.05
   4.80  6.34      6.50  6.80      6.90  7.00      7.00  7.30      7.50   8.10
   5.00  6.35      6.50  6.80      6.90  7.00      7.00  7.30      7.50   8.20●
   5.00  6.36      6.50  6.80      6.93  7.00      7.00  7.30      7.50   8.26
   5.00  6.40      6.50  6.80      6.93  7.00      7.00  7.30      7.50   8.26
   5.00  6.40      6.50  6.80      6.93  7.00      7.00  7.33      7.50   8.30
   5.32  6.40      6.50  6.80      6.94  7.00      7.00  7.35      7.50   8.50
   5.46  6.40      6.50  6.80      6.95  7.00      7.04  7.39      7.50   8.50
   5.50  6.41      6.55  6.80      6.96  7.00      7.05  7.40      7.50   8.50
   5.50  6.47      6.60  6.81      6.96  7.00      7.09  7.40      7.50   9.00
   5.50  6.50      6.60  6.85      6.99  7.00      7.10  7.40      7.50   9.00
   5.50  6.50      6.60  6.87      7.00  7.00      7.10  7.40      7.50   9.00
   5.50  6.50      6.60  6.88      7.00  7.00      7.10  7.40      7.50   9.00
   5.60  6.50      6.60  6.89      7.00  7.00      7.10  7.40      7.50  10.10
   5.61  6.50      6.60  6.90      7.00  7.00      7.10  7.43      7.60  14.10●
   5.69  6.50      6.60  6.90      7.00  7.00      7.10  7.46      7.60  38.00●
   5.80● 6.50      6.60  6.90      7.00  7.00      7.10  7.50      7.60  46.90
   5.80  6.50      6.63  6.90      7.00  7.00      7.14  7.50      7.70
   5.80            6.65            7.00            7.19            7.70
   5.80            6.65            7.00            7.20            7.70
   5.95            6.69            7.00            7.20            7.70
   6.00            6.70            7.00            7.20            7.72
   6.00            6.70            7.00            7.20            7.75
   6.00            6.70            7.00            7.20            7.75
   6.00            6.70            7.00            7.20            7.80
   6.00            6.70            7.00            7.20            7.80
   6.00            6.70            7.00            7.20            7.80
   6.00            6.70            7.00            7.20            7.80
   6.07            6.70            7.00            7.20            7.82
   6.10            6.70            7.00            7.20            7.88
   6.10            6.70            7.00            7.20            7.90
   6.10            6.70            7.00            7.20            7.90
   6.20            6.70            7.00            7.20            7.91
   6.20            6.74            7.00            7.22            8.00
   6.20            6.75            7.00            7.25            8.00
   6.20            6.75            7.00            7.25            8.00
   6.22            6.75            7.00            7.25            8.00
   6.25            6.77            7.00            7.25            8.00
   6.25            6.80            7.00            7.25            8.00
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INTER-LABORATORY STUDY      378

POLLUTANT - CO                            UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N               344        RANGE            7.20         C.I.(UPPER)  20.44
TRUE-VALUE    20.23        VARIANCE          .96         C.I.(LOWER)   20.23
MEAN          20.33        STD. DEV.         .98         SKEWNESS       -.78
MEDIAN        20.30        COEF. VAR.       4.81         ACCURACY        .35

DATA IN ASCENDING ORDER

      16.00● 19.50    20.00  20.04    20.20  20.40    20.50  20.80    21.00  21.75
      16.20  19.53    20.00  20.05    20.20  20.40    20.50  20.80    21.00  21.79
      16.80  19.60    20.00  20.10    20.20  20.40    20.50  20.80    21.00  21.80
      17.00● 19.60    20.00  20.10    20.21  20.40    20.50  20.80    21.00  21.80
      17.00  19.60    20.00  20.10    20.21  20.40    20.50  20.80    21.00  21.94
      17.39  19.60    20.00  20.10    20.22  20.40    20.50  20.82    21.00  22.00
      17.50  19.67    20.00  20.10    20.24  20.47    20.50  20.90    21.00  22.00
      17.60  19.70    20.00  20.10    20.25  20.50    20.50  20.90    21.00  22.00
      17.70  19.70    20.00  20.10    20.25  20.50    20.50  20.90    21.00  22.05
      17.80  19.72    20.00  20.10    20.25  20.50    20.50  20.96    21.00  22.19
      17.83  19.75    20.00  20.10    20.25  20.50    20.50  20.98    21.10  22.20
      18.00  19.75    20.00  20.13    20.25  20.50    20.50  21.00    21.13  22.70
      18.00  19.75    20.00  20.14    20.25  20.50    20.50  21.00    21.20  22.78
      18.20  19.80    20.00  20.15    20.27  20.50    20.50  21.00    21.25  22.80
      18.30  19.80    20.00  20.18    20.30  20.50    20.54  21.00    21.30  22.89
      18.72  19.80    20.00  20.20    20.30  20.50    20.55  21.00    21.30  23.40
      18.75  19.80    20.00  20.20    20.30  20.50    20.56  21.00    21.30  23.50●
      18.80  19.90    20.00  20.20    20.30  20.50    20.60  21.00    21.30  40.20●
      18.90  19.90    20.00  20.20    20.30  20.50    20.60  21.00    21.31
      18.93  19.90    20.00  20.20    20.30  20.50    20.60  21.00    21.34
      19.00  19.90    20.00  20.20    20.30  20.50    20.60  21.00    21.40
      19.00  19.94    20.00  20.20    20.30  20.50    20.60  21.00    21.40
      19.00  20.00    20.00  20.20    20.30  20.50    20.60  21.00    21.48
      19.00           20.00           20.30           20.60           21.50
      19.00           20.00           20.30           20.60           21.50
      19.10           20.00           20.30           20.65           21.50
      19.10           20.00           20.30           20.70           21.50
      19.20           20.00           20.30           20.70           21.60
      19.20           20.00           20.30           20.70           21.60
      19.20           20.00           20.30           20.70           21.60
      19.20           20.00           20.30           20.70           21.60
      19.20           20.00           20.30           20.70           21.64
      19.30           20.00           20.35           20.70           21.70
      19.40           20.00           20.38           20.71           21.70
      19.40           20.00           20.39           20.71           21.70
      19.40           20.00           20.40           20.72           21.70
      19.40           20.00           20.40           20.72           21.70
      19.50           20.00           20.40           20.72           21.70
      19.50           20.00           20.40           20.73           21.70
      19.50           20.00           20.40           20.75           21.70
      19.50           20.00           20.40           20.80           21.70
      19.50           20.00           20.40           20.80           21.74
      19.50           20.00           20.40           20.80           21.75
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INTER-LABORATORY STUDY      378

POLLUTANT - CO                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N              340          RANGE           42.65         C.I.(UPPER)  42.57
TRUE-VALUE   42.08          VARIANCE        10.17         C.I.(LOWE  R)  41.86
MEAN         42.20          STD. DEV.        3.19         SKEWNESS      -8.80
MEDIAN       42.30          COEF. VAR.       7.56         ACCURACY        .57

DATA IN ASCENDING ORDER

      .67  41.06     41.50  42.00     42.10  42.40     42.50  43.00     43.50  45.10
     4.75  41.10     41.50  42.00     42.10  42.40     42.50  43.00     43.50  45.20
     5.00  41.15     41.50  42.00     42.10  42.44     42.59  43.00     43.50  45.30
     6.80  41.20     41.50  42.00     42.14  42.45     42.60  43.00     43.50  45.31
    33.80  41.20     41.50  42.00     42.16  42.46     42.60  43.00     43.50  45.40
    34.20  41.20     41.50  42.00     42.18  42.46     42.60  43.00     43.50  45.40
    35.65  41.20     41.50  42.00     42.18  42.50     42.62  43.00     43.50  45.50
    37.43  41.25     41.50  42.00     42.20  42.50     42.64  43.20     43.50  45.50
    38.40  41.30     41.60  42.00     42.20  42.50     42.70  43.25     43.60  45.60
    38.50  41.30     41.60  42.00     42.20  42.50     42.70  43.30     43.60  45.70
    38.70  41.37     41.60  42.00     42.20  42.50     42.70  43.30     43.60  45.80
    39.00  41.40     41.70  42.00     42.20  42.50     42.70  43.30     43.60  46.49
    39.00  41.43     41.70  42.00     42.20  42.50     42.70  43.40     43.60  46.50
    39.00  41.46     41.75  42.00     42.20  42.50     42.70  43.40     43.64  46.50
    39.40  41.50     41.75  42.00     42.20  42.50     42.70  43.40     43.70  46.70
    39.40  41.50     41.75  42.01     42.20  42.50     42.70  43.40     43.70  47.02
    39.50  41.50     41.79  42.03     42.25  42.50     42.72  43.42     43.80  47.25
    39.50  41.50     41.80  42.05     42.25  42.50     42.75  43.42     43.80  47.40
    39.88  41.50     41.80  42.10     42.25  42.50     42.80  43.50     43.80  84.30
    39.90  41.50     41.80  42.10     42.25  42.50     42.80  43.50     43.83
    40.00  41.50     41.80  42.10     42.29  42.50     42.80  43.50     43.86
    40.00  41.50     41.80  42.10     42.30  42.50     42.80  43.50     43.91
    40.00            41.84            42.30            42.80            44.00
    40.00            41.88            42.30            42.80            44.00
    40.00            41.90            42.30            42.60            44.00
    40.00            41.90            42.30            42.80            44.00
    40.50            41.90            42.30            42.80            44.00
    40.50            41.90            42.30            42.60            44.02
    40.50            41.90            42.30            42.80            44.04
    40.70            41.90            42.30            42.81            44.10
    40.70            41.90            42.30            42.83            44.10
    40.75            41.93            42.30            42.90            44.10
    40.80            41.97            42.33            42.90            44.15
    40.90            42.00            42.35            42.99            44.16
    41.00            42.00            42.36            43.00            44.18
    41.00            42.00            42.39            43.00            44.30
    41.00            42.00            42.40            43.00            44.40
    41.00            42.00            42.40            43.00            44.53
    41.00            42.00            42.40            43.00            44.60
    41.00            42.00            42.40            43.00            44.70
    41.00            42.00            42.40            43.00            44.80
    41.00            42.00            42.40            43.00            45.00
    41.00            42.00            42.40            43.00            45.00
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INTER-LABORATORY STUDY      978

POLLUTANT - CO                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                331         RANGE            8.50        C.I.(UPPER)    3.78
TRUE-VALUE      3.82         VARIANCE          .63        C.I.(LOWE  R)    3.61
MEAN            3.69         STD. DEV.         .80        SKEWNESS       2.77
MEDIAN          3.60         COEF. VAR.      21.54        ACCURACY      -5.76

DATA IN ASCENDING ORDER


       1.50   3.00     3.19   3.43     3.50   3.70     3.80   4.00     4.00   4.70
       1.90   3.00     3.20   3.44     3.50   3.70     3.80   4.00     4.00   5.00
       2.00●  3.00     3.20   3.44     3.50   3.70     3.80   4.00     4.00   5.00
       2.10   3.00     3.20   3.45     3.50   3.70     3.81   4.00     4.01   5.00
       2.15   3.00     3.20   3.45     3.50   3.70     3.86   4.00     4.08   5.00
       2.20   3.00     3.20   3.45     3.50   3.70     3.89   4.00     4.10   5.10
       2.29   3.00     3.20   3.48     3.50   3.70     3.90●  4.00     4.10   5.10
       2.50●  3.00     3.20   3.49     3.50   3.74     3.90   4.00     4.10   5.62
       2.50   3.01     3.20   3.50     3.50   3.75     3.90   4.00     4.10   5.88
       2.50   3.04     3.20   3.50     3.50   3.75     3.90   4.00     4.13   6.00●
       2.50   3.04     3.22   3.50     3.51   3.75     3.90   4.00     4.16   6.00
       2.50   3.04     3.25   3.50     3.52   3.75     3.90   4.00     4.17   6.00
       2.60   3.04     3.25   3.50     3.53   3.75     3.90   4.00     4.20   6.00
       2.60   3.10     3.25   3.50     3.55   3.75     3.90   4.00     4.20   6.30
       2.60   3.10     3.25   3.50     3.56   3.75     3.90   4.00     4.20   6.90
       2.60   3.10     3.29   3.50     3.57   3.75     3.90   4.00     4.20   7.00●
       2.60   3.10     3.30   3.50     3.57   3.77     3.90   4.00     4.20   7.39●
       2.61●  3.10     3.30   3.50     3.57   3.79     3.90   4.00     4.20   7.60●
       2.62   3.10     3.30   3.50     3.59   3.80     3.90   4.00     4.20   7.71●
       2.65   3.10     3.30   3.50     3.60   3.80     3.91   4.00     4.20   7.83
       2.67   3.10     3.30   3.50     3.60   3.80     3.91   4.00     4.25   8.00
       2.70   3.12     3.30   3.50     3.60   3.80     3.93   4.00     4.25  10.00
       2.75   3.13     3.30   3.50     3.60   3.80     3.94   4.00     4.25  11.00●
       2.79   3.13     3.30   3.50     3.60   3.80     3.95   4.00     4.29
       2.80   3.15     3.30   3.50     3.60   3.80     3.99   4.00     4.30
       2.80   3.19     3.31   3.50     3.60   3.80     4.00   4.00     4.30
       2.80            3.33            3.60            4.00            4.30
       2.84            3.34            3.60            4.00            4.30
       2.87            3.35            3.60            4.00            4.35
       2.90            3.35            3.60            4.00            4.35
       2.90            3.36            3.60            4.00            4.35
       2.90            3.37            3.60            4.00            4.38
       2.90            3.38            3.62            4.00            4.40
       2.96●           3.40            3.64            4.00            4.40
       3.00            3.40            3.65            4.00            4.43
       3.00            3.40            3.66            4.00            4.50
       3.00            3.40            3.66            4.00            4.50
       3.00            3.40            3.68            4.00            4.50
       3.00            3.40            3.70            4.00            4.50
       3.00            3.40            3.70            4.00            4.50
       3.00            3.42            3.70            4.00            4.50
       3.00            3.42            3.70            4.00            4.50
       3.00            3.42            3.70            4.00            4.58
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INTEF-LAFORATORY STUFY      978

POLLUTANT - CO                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                 331       RANGE          32.10        C.I.(UPPER)  15.03
TRUE-VALUE      14.56       VARIANCE        3.27        C.I.(LOWE  R)  14.65
MEAN            14.84       STD. DEV.       1.81        SKEWNESS      11.92
MEDIAN          14.80       COEF. VAR.     12.18        ACCURACY       1.65

DATA IN ASCENDING ORDER

     8.51● 13.75    14.10  14.50    14.56  14.88    15.00  15.20    15.50  16.17
     9.10● 13.80    14.10  14.50    14.56  14.90    15.00  15.20    15.50  16.24
    11.00● 13.80    14.10  14.50    14.58  14.90    15.00  15.20    15.50  16.30
    11.30  13.80    14.11  14.50    14.59  14.90    15.00  15.22    15.50  16.30
    11.74● 13.80    14.12  14.50    14.60  14.90    15.00  15.23    15.50  16.30
    12.07  13.80    14.13  14.50    14.60  14.90    15.00  15.30    15.50  16.40
    12.09● 13.84    14.17  14.50    14.60  14.90    15.00  15.30    15.50  16.50
    12.43  13.90    14.20● 14.50    14.60  14.90    15.00  15.30    15.50  16.52
    12.50  13.91    14.20  14.50    14.60  14.90    15.00  15.30    15.50  16.60
    12.78  13.99    14.20  14.50    14.60  14.90    15.00  15.30    15.50  16.70
    12.79  14.00    14.20  14.50    14.60  14.96    15.00  15.30    15.50  17.00
    12.80  14.00    14.20  14.50    14.62  14.99    15.00  15.32    15.50  17.00
    12.90  14.00    14.20  14.50    14.63  15.00    15.00  15.33    15.50  17.00
    12.90  14.00    14.25  14.50    14.65  15.00    15.00  15.40    15.50  17.08
    13.00  14.00    14.25  14.50    14.66  15.00    15.00  15.40    15.50  18.00
    13.11  14.00    14.25  14.50    14.66  15.00    15.00  15.40    15.50  19.00
    13.20  14.00    14.25  14.50    14.67  15.00    15.00  15.40    15.52  19.00●
    13.20  14.00    14.25  14.50    14.69  15.00    15.00  15.40    15.60  19.00●
    13.25  14.00    14.25  14.50    14.70  15.00    15.00  15.50    15.60  19.00●
    13.29  14.00    14.30  14.50    14.70  15.00    15.00  15.50    15.60  20.62●
    13.30  14.00    14.30  14.50    14.70  15.00    15.00  15.50    15.60  21.31●
    13.30  14.00    14.30  14.50    14.70  15.00    15.00  15.50    15.66  22.71
    13.34  14.00    14.30  14.50    14.70  15.00    15.00  15.50    15.70  32.10●
    13.39  14.05    14.30  14.50    14.70  15.00    15.00  15.50    15.70  43.40
    13.39  14.07    14.30  14.50    14.73  15.00    15.00  15.50    15.70
    13.40  14.10    14.30  14.52    14.74  15.00    15.00  15.50    15.70
    13.40           14.30           14.75           15.00           15.75
    13.40           14.31           14.75           15.01           15.80
    13.48           14.38           14.75           15.05           15.80
    13.50           14.38           14.80           15.09           15.80
    13.50           14.40           14.80           15.10           15.80
    13.50           14.40           14.80           15.10           15.80
    13.50           14.40           14.80           15.10           15.80
    13.58           14.43           14.80           15.10           15.80
    13.60           14.45           14.80           15.12           15.90
    13.60           14.46           14.80           15.13           15.95
    13.60           14.48           14.80           15.13           16.00
    13.60           14.49           14.80           15.20           16.00
    13.60           14.50           14.80           15.20           16.00
    13.60           14.50           14.81           15.20           16.00
    13.65           14.50           14.84           15.20           16.00
    13.66           14.50           14.84           15.20           16.10
    13.70           14.50           14.85           15.20           16.10
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INTER-LABORATORY STUDY      978

POLLUTANT - CO                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                 371          RANGE            25.50         C.I.(UPPER)  37.14
TRUE-VALUE      36.45          VARIANCE          2.95         C.I.(LOWE  R)  36.77
MEAN            36.96          STD. DEV.         1.72         SKEWNESS      -4.83
MEDIAN          36.92          COEFF. VAR.       4.65         ACCURACY       1.29

DATA IN ASCENDING ORDER

    16.50  35.55    36.00  36.50    36.70  37.00    37.20  37.52    38.00  39.50
    22.60● 35.57    36.06  36.50    36.70  37.00    37.20  37.55    38.00  39.52
    30.52● 35.60    36.06  36.50    36.70  37.00    37.20  37.60    38.00  39.55
    31.00● 35.63    36.09  36.50    36.70  37.00    37.20  37.60    38.00  39.60
    31.83● 35.70    36.09  36.50    36.70  37.00    37.20  37.60    38.00  39.91
    32.00● 35.72    36.10  36.50    36.70  37.00    37.20  37.62    38.00  40.00
    32.65  35.72    36.10  36.50    36.70  37.00    37.25  37.65    38.00  40.00
    33.40  35.80    36.10  36.50    36.70  37.00    37.25  37.70    38.00  40.00
    33.74  35.85    36.10  36.50    36.70  37.00    37.25  37.70    38.10  40.00
    33.91  36.00●   36.10  36.50    36.70  37.00    37.25  37.70    38.10  40.00
    34.44  36.00    36.15  36.50    36.70  37.00    37.30  37.75    38.10  40.20
    34.50  36.00    36.15  36.50    36.72  37.00    37.30  37.80    38.10  40.40
    34.50  36.00    36.20  36.51    36.75  37.00    37.30  37.80    38.17  40.49
    34.50  36.00    36.20  36.54    36.75  37.00    37.30  37.80    38.20  40.50
    34.50  36.00    36.20  36.54    36.80  37.00    37.30  37.80    38.26  41.10
    34.50  36.00    36.20  36.54    36.80  37.00    37.30  37.83    38.30  41.20
    34.61  36.00    36.20  36.55    36.80  37.00    37.35  37.90    38.30  41.50●
    34.70  36.00    36.25  36.56    36.80  37.00    37.35  38.00    38.30  42.00
    34.70  36.00    36.28  36.56    36.80  37.01    37.40  38.00    38.35  42.00●
    35.00  36.00    36.30  36.60    36.80  37.04    37.40  38.00    38.36  42.37●
    35.00  36.00    36.30  36.60    36.86  37.05    37.40  38.00    38.40  43.00●
    35.00  36.00    36.30  36.60    36.87  37.10    37.40  38.00    38.50  46.09●
    35.10  36.00    36.31  36.60    36.88  37.10    37.40  38.00    38.50  56.48
    35.20  36.00    36.33  36.63    36.89  37.10    37.40  38.00    38.50  72.40●
    35.20  36.00    36.39  36.63    36.90  37.16    37.40  38.00    38.50
    35.27  36.00    36.40  36.70    36.90  37.16    37.40  38.00    38.60
    35.30           36.40           36.90           37.40           38.60
    35.40           36.40           36.90           37.40           38.60
    35.40           36.40           36.90           37.44           38.60
    35.40           36.40           36.90           37.50           38.70
    35.42           36.42           36.90           37.50           38.70
    35.44           36.49           36.92           37.50           38.80
    35.50           36.50           36.92           37.50           38.90
    35.50           36.50           36.95           37.50           39.00
    35.50           36.50           36.99           37.50           39.00
    35.50           36.50           37.00           37.50           39.00
    35.50           36.50           37.00           37.50           39.26
    35.50           36.50           37.00           37.50           39.29
    35.50           36.50           37.00           37.50           39.30
    35.50           36.50           37.00           37.50           39.37
    35.50           36.50           37.00           37.50           39.50
    35.50           36.50           37.00           37.50           39.50
    35.55           36.50           37.00           37.50           39.50
```

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INTER-LABORATORY STUDY      178

POLLUTANT - PB                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                   61       RANGE            7.32        C.I.(UPPER)   6.62
TRUE-VALUE        6.60       VARIANCE          .77        C.I.(LOWE  R)   6.18
MEAN              6.40       STD. DEV.         .88        SKEWNESS     -2.74
MEDIAN            6.42       COEF. VAR.      13.69        ACCURACY     -2.73

DATA IN ASCENDING ORDER

        1.38             6.12             6.36             6.60             6.90
        1.80 ●           6.13             6.36             6.60             6.92
        4.37 ●           6.13             6.36             6.66             7.10
        5.08             6.14             6.36             6.69             7.11
        5.10             6.17             6.38             6.69             7.13
        5.39             6.20             6.41             6.70             7.28
        5.40             6.23             6.42             6.70             7.46
        5.51 ●           6.23             6.45             6.72             8.10
        5.64 ●           6.26             6.48             6.74             8.70
        5.69             6.30             6.48             6.75             9.22 ●
        5.91             6.30             6.50             6.76            22.61 ●
        6.00             6.30             6.52             6.78            39.69 ●
        6.00             6.30             6.54             6.84
        6.12             6.32             6.56             6.85
```

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INTER-LABORATORY STUDY      178

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                  61        RANGE           14.76         C.I.(UPPER)  12.36
TRUE-VALUE      12.60        VARIANCE         3.15         C.I.(LOWE  R)  11.47
MEAN            11.92        STD. DEV.        1.77         SKEWNESS     -2.68
MEDIAN          12.12        COEF. VAR.      14.89         ACCURACY     -3.81

DATA IN ASCENDING ORDER

        2.33             11.40             12.00             12.40             12.75
        3.32 ●           11.42             12.00             12.43             12.76
        6.36             11.50             12.00             12.47             12.80
        8.58 ●           11.52             12.00             12.48             12.80
        8.62 ●           11.55             12.04             12.48             12.96
        9.06             11.61             12.07             12.48             13.20
       10.20             11.61             12.12             12.48             14.10
       10.60             11.70             12.14             12.50             14.40
       10.80 ●           11.70             12.20             12.56             16.22 ●
       11.05             11.80             12.23             12.58             17.09
       11.16             11.88             12.29             12.60
       11.40             11.90             12.30             12.63
       11.40             12.00             12.30             12.66
       11.40             12.00             12.35             12.74
```

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INTER-LABORATORY STUDY      178

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                  22          RANGE            1.19          C.I.(UPPER)      .25
TRUE-VALUE        .00          VARIANCE          .07          C.I.(LOWE  R)      .04
MEAN              .14          STD. DEV.         .26          SKEWNESS        3.12
MEDIAN            .05          COEF. VAR.     180.59          ACCURACY         .00

DATA IN ASCENDING ORDER

        .01             .02             .05             .12             .42
        .01             .02             .06             .15            1.20
        .01             .03             .08             .18           18.66 ●
        .01             .03             .10             .19
        .01             .04             .10             .31
```

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INTER-LABORATORY STUDY      178

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 62         RANGE           13.35        C.I.(UPPER)  10.17
TRUE-VALUE     10.20         VARIANCE         3.25        C.I.(LOWE  R)   9.27
MEAN            9.72         STD. DEV.        1.80        SKEWNESS     -2.90
MEDIAN         10.04         COEF. VAR.      18.56        ACCURACY     -1.57

DATA IN ASCENDING ORDER

      .57 ●          9.10           9.78          10.09          10.48
     1.10            9.12 ●         9.88          10.10          10.55
     1.27 ●          9.34           9.90          10.10          10.58
     1.93            9.36           9.90          10.16          10.60
     2.50 ●          9.36           9.90          10.20          10.62
     5.64            9.42           9.90          10.20          10.80
     7.41 ●          9.42           9.93          10.24          10.80
     8.20 ●          9.48          10.00          10.26          10.80
     8.96            9.50          10.03          10.26          11.20
     8.99            9.60          10.05          10.28          11.20
     9.00            9.60          10.06          10.31          11.65
     9.00            9.60          10.08          10.34          13.44 ●
     9.00            9.62          10.08          10.39          14.45
     9.06            9.70          10.08          10.40
```

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INTER-LABORATORY STUDY      178

POLLUTANT - PB                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                 62     RANGE           1.82     C.I.(UPPER)       .70
TRUE-VALUE       .60     VARIANCE         .05     C.I.(LOWE  R)     .58
MEAN             .64     STD. DEV.        .23     SKEWNESS         3.46
MEDIAN           .60     COEF. VAR.     35.65     ACCURACY          .00

DATA IN ASCENDING ORDER

                                                             .70
                                                .62          .70
       .16         .54          .60             .63          .72
       .20 ●       .54          .60             .63          .73
       .23         .55          .60             .63          .79
       .38 ●       .56          .60             .63          .81
       .42         .57          .60             .63          .86
       .42 ●       .57          .60             .64          .87
       .45         .57          .60             .65          .94
       .46 ●       .58          .60             .66         1.29
       .48         .58          .60             .67         1.98
       .50         .58          .61             .67         1.98 ●
       .50         .59          .61             .67         2.97 ●
       .50         .59          .61             .67 ●
       .53         .60          .62             .69
       .54         .60          .62
```

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INTER-LABORATORY STUDY      178

POLLUTANT - PB                        UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  8

N                 61        RANGE            1.97        C.I.(UPPER)   2.06
TRUE-VALUE      2.04        VARIANCE          .10        C.I.(LOWE  R)   1.90
MEAN            1.98        STD. DEV.         .31        SKEWNESS     -3.22
MEDIAN          2.04        COEF. VAR.      15.82        ACCURACY       .00

DATA IN ASCENDING ORDER

       .43          1.86          2.00          2.08          2.19
       .46 ●        1.86          2.00          2.08          2.20
       .63          1.86          2.02          2.09          2.21
      1.45 ●        1.92          2.02          2.10          2.22
      1.50          1.92          2.04          2.10          2.23
      1.70          1.93          2.04          2.10          2.27
      1.74 ●        1.95          2.04          2.10          2.31
      1.75          1.96          2.04          2.10          2.39
      1.77 ●        1.96          2.04          2.10          2.40
      1.80          1.97          2.04          2.10          2.72 ●
      1.80          1.98          2.04          2.15          8.13 ●
      1.80          1.98          2.05          2.15         10.20 ●
      1.83          1.98          2.06          2.16
      1.86          2.00          2.08          2.16
```

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INTER-LABORATORY STUDY      678

POLLUTANT - PB                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  9

N                  64        RANGE            1.85        C.I.(UPPER)   1.57
TRUE-VALUE       1.50        VARIANCE          .05        C.I.(LOWE  R)   1.46
MEAN             1.51        STD. DEV.         .22        SKEWNESS      -.57
MEDIAN           1.52        COEF. VAR.      14.55        ACCURACY      1.00

DATA IN ASCENDING ORDER

      .48            1.41            1.50            1.56            1.62
      .94 ●          1.41            1.50            1.56            1.62
     1.10 ●          1.44            1.50            1.56            1.62
     1.10            1.44            1.50            1.56            1.62
     1.12 ●          1.44            1.50            1.56            1.63
     1.26            1.44            1.51            1.57            1.65
     1.27            1.44            1.51            1.58            1.66
     1.31            1.45            1.52            1.58            1.83 ●
     1.31            1.45            1.52            1.58            1.86
     1.35            1.46            1.53            1.59            1.92
     1.38            1.46            1.53            1.60            2.08
     1.38            1.46            1.55            1.60            2.33
     1.39            1.47            1.55            1.61
     1.39            1.49            1.55            1.61
```

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INTER-LABORATORY STUDY      678

POLLUTANT - PB                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  0

N                   64      RANGE              4.43        C.I.(UPPER)      .61
TRUE-VALUE         .42      VARIANCE            .27        C.I.(LOWE  R)      .36
MEAN               .49      STD. DEV.           .52        SKEWNESS        7.29
MEDIAN             .42      COEF. VAR.       105.93        ACCURACY        -.00

DATA IN ASCENDING ORDER

         .06            .40             .42             .44            .48
         .10            .40             .42             .44            .48
         .17 ●          .40             .42             .44            .48
         .29            .41             .42             .45            .49
         .30            .41             .42             .45            .54
         .30            .41             .42             .45            .60 ●
         .35            .41             .42             .45            .60
         .36            .41             .42             .45            .60
         .36            .41             .43             .45            .60
         .37 ●          .41             .44             .46            .61
         .38            .42             .44             .46           1.80 ●
         .39            .42             .44             .47           4.49
         .40            .42             .44             .47
         .40            .42             .44             .48
```

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INTER-LABORATORY STUDY     678

POLLUTANT - PB                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                  15         RANGE           9.71        C.I.(UPPER)    2.00
TRUE-VALUE        .00         VARIANCE        6.20        C.I.(LOWE  R)   -.52
MEAN              .74         STD. DEV.       2.49        SKEWNESS       3.10
MEDIAN            .05         COEF. VAR.    335.69        ACCURACY        .00

DATA IN ASCENDING ORDER

        .01              .01              .05              .15
        .01              .02              .06              .76
        .01              .03              .12             1.20
        .01              .05              .12             9.72
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INTER-LABORATORY STUDY     678

POLLUTANT - PB                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                  64        RANGE           13.12        C.I.(UPPER)  10.28
TRUE-VALUE       9.90        VARIANCE         3.78        C.I.(LOWE  R)  9.33
MEAN             9.80        STD. DEV.        1.94        SKEWNESS      -1.52
MEDIAN           9.90        COEF. VAR.      19.82        ACCURACY        .00

DATA IN ASCENDING ORDER

      1.88          9.06          9.72         10.10         10.68
      1.96          9.12          9.72         10.10         10.68
      4.00●         9.14          9.72         10.14         10.69
      6.25          9.30          9.85         10.23         10.73
      6.85●         9.38          9.90         10.25         11.10
      7.49          9.57          9.90         10.30         11.40
      7.50●         9.59          9.90         10.32         11.74
      8.40          9.60          9.90         10.32         12.60
      8.52          9.61          9.90         10.36         13.20●
      8.62          9.63          9.93         10.39         13.31
      9.00          9.64          9.96         10.50         14.60
      9.00          9.68          9.99         10.50         15.00
      9.00          9.68         10.00         10.50
      9.00          9.72         10.00         10.65
```

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INTER-LABORATORY STUDY      678

POLLUTANT - PB                              UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  7

N                   65        RANGE            15.57          C.I.(UPPER)  11.99
TRUE-VALUE       12.00        VARIANCE          2.94          C.I.(LOWE  R)  11.16
MEAN             11.58        STD. DEV.         1.71          SKEWNESS       -1.60
MEDIAN           11.65        COEF. VAR.       14.80          ACCURACY       -2.92

DATA IN ASCENDING ORDER

          2.43           10.62●         11.47          12.00          12.47
          2.96●          10.62          11.47          12.00          12.57
          8.26●          10.90          11.52          12.00          12.70
          8.40●          11.00          11.55          12.00          12.72
          8.85           11.07          11.55          12.00          12.72
          9.17           11.07          11.58          12.00          12.75
          9.49           11.16          11.60          12.03          12.78
          9.60           11.16          11.64          12.05          12.80
          9.80           11.24          11.65          12.09          12.80
         10.20           11.34          11.67          12.15          13.50
         10.35           11.34          11.70          12.16          13.50
         10.54           11.40          11.88          12.27          13.91
         10.56           11.40          11.90          12.28          18.00
         10.56           11.40          11.90          12.47
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INTER-LABORATORY STUDY     1078

POLLUTANT - SO2                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                95      RANGE          42.45      C.I.(UPPER)  15.24
TRUE-VALUE     9.07      VARIANCE       45.95      C.I.(LOWE  R)  12.51
MEAN          13.87      STD. DEV.       6.78      SKEWNESS      1.08
MEDIAN        13.10      COEF. VAR.     48.88      ACCURACY     44.43

DATA IN ASCENDING ORDER

         .55          10.00          12.77          14.44          18.34
        1.17          10.12          12.81          14.70          18.58
        1.58          10.20          12.94          14.90          18.70
        2.62          10.40          13.10 ●        15.00          19.30
        3.50          10.48          13.10          15.15          19.50
        3.94          10.48          13.10          15.39          22.48
        4.00          11.20          13.10          15.46          22.87
        4.42          11.26          13.10          15.58          23.45
        5.24          11.37 ●        13.11          15.72          26.20
        5.51          11.54          13.26          15.72          26.67
        6.48          11.66          13.34          15.72          27.00
        7.90          11.70          13.44          15.72          27.47
        8.03          12.00          13.48          15.72          27.47
        8.30          12.38          13.70          16.20          28.77
        9.40          12.53          14.00          16.67          29.40 ●
        9.40          12.54          14.07          16.70          30.40
       10.00          12.57          14.24          17.89          43.00
       10.00          12.62          14.36          18.34
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INTER-LABORATORY STUDY     1078

POLLUTANT - SO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                101          RANGE            61.56          C.I.(UPPER)  38.93
TRUE-VALUE     38.80          VARIANCE        101.02          C.I.(LOWE  R)  35.01
MEAN           36.97          STD. DEV.        10.05          SKEWNESS       -.01
MEDIAN         38.20          COEF. VAR.       27.19          ACCURACY      -1.55

DATA IN ASCENDING ORDER

        8.90              29.76              36.48              38.98              44.23
       10.00              30.84              36.50              39.30              44.54
       10.40              31.44              36.66              39.30              44.54
       13.10 ●            31.58              36.68              39.30              45.30
       15.66              32.00              36.68              39.30              45.55
       17.35              32.00              36.70              39.30              46.00
       18.20 ●            33.00              37.11              40.50              46.15
       20.50              33.20              37.30              40.50              48.33
       21.67              33.40              37.90              40.86              49.78
       22.28              34.06              38.00              40.93              51.55
       22.52 ●            34.06              38.26              40.95              54.00
       22.76              34.72              38.30              41.67              60.80
       25.00              34.77              38.34              41.92              63.33
       25.00              35.00              38.40              41.92              70.46
       25.63              35.00              38.54              42.07              97.40 ●
       26.20              35.40              38.57              42.48
       27.30              36.00              38.63              42.70
       28.58              36.17              38.75              43.69
       28.90              36.32              38.83              44.00
       29.47              36.40              38.86              44.00
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INTER-LABORATORY STUDY     1078

POLLUTANT - SO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N               100          RANGE              74.27        C.I.(UPPER)  84.47
TRUE-VALUE    88.90          VARIANCE          132.05        C.I.(LOWER)   79.96
MEAN          82.21          STD. DEV.          11.49        SKEWNESS        -.56
MEDIAN        82.13          COEF. VAR.         13.98        ACCURACY       -7.62

DATA IN ASCENDING ORDER

      11.37 ●          75.28          80.40          83.84          89.47
      40.40            75.70          80.46          84.00          89.98
      41.92 ●          76.16          80.57          85.00          89.99
      49.14 ●          76.63          80.84          85.90          90.06
      49.78            76.90          81.00          86.00          90.75
      62.42            77.00          81.20          86.25          91.41
      62.60            77.00          81.22          86.46          91.70
      62.88            77.00          81.22          86.46          91.70
      64.13            77.80          81.39          86.61          91.70
      65.85            78.10          81.47          86.70          91.76
      73.07            78.30          81.86          86.81          96.15
      73.30            78.50          82.30          86.97         100.20
      73.36            78.53          82.33          87.37         102.18
      73.36            78.60          82.46          87.42         104.17
      73.36            79.14          83.20          88.00         105.30
      74.00            79.76          83.33          88.31         110.00
      74.10            79.83          83.40          88.32         110.00
      74.30            80.14          83.70          89.08         164.40 ●
      74.33            80.30          83.84          89.20
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INTER-LABORATORY STUDY     1078

POLLUTANT - SO2                         UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 99      RANGE          89.90        C.I.(UPPER) 128.29
TRUE-VALUE    128.30      VARIANCE      178.20        C.I.(LOWE  R) 123.04
MEAN          125.66      STD. DEV.      13.35        SKEWNESS         -.41
MEDIAN        125.76      COEF. VAR.     10.62        ACCURACY        -1.98

DATA IN ASCENDING ORDER

      62.88 ●      117.00       123.96       128.38       134.90
      78.60        117.70       124.00       130.00       135.54
      79.80        117.80       124.00       130.00       135.77
      86.46 ●      119.00       124.55       130.08       136.24
      93.01        119.28       124.62       130.21       136.24
      99.00        120.00       124.70       130.30       136.78
      99.36 ●      120.10       125.10       130.81       137.00
     103.50        120.96       125.20       131.05       138.08
     103.87        121.00       125.30       131.55       138.46
     106.69        121.17       125.70       131.60       139.82
     110.04        121.49       125.76       132.32       142.31
     110.04        121.50       125.76       132.50       144.65
     111.10        121.82       125.83       132.70       145.00
     112.58        122.72       126.50       132.85       149.40
     112.66        122.86       126.90       133.33       151.96
     113.50        123.14       127.40       133.62       165.00
     113.97        123.14       127.68       133.62       250.50 ●
     114.00        123.14       128.10       133.62
     116.10        123.90       128.38       133.88
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INTER-LABORATORY STUDY    1078

POLLUTANT - SO2                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                100         RANGE          116.32        C.I.(UPPER) 172.48
TRUE-VALUE   192.20         VARIANCE       332.53        C.I.(LOWE  R) 165.33
MEAN         168.91         STD. DEV.       18.24        SKEWNESS        -.09
MEDIAN       169.45         COEF. VAR.      10.80        ACCURACY      -11.84

DATA IN ASCENDING ORDER

     86.46 ●        156.30          166.67          172.92          183.33
    110.34          156.82          166.90          173.00          183.40
    119.45 ●        157.00          167.15          174.61          183.48
    120.15 ●        157.40          167.67          175.54          183.70
    131.00          158.67          167.68          175.54          184.01
    135.13          158.70          167.68          176.64          184.16
    137.42          159.00          167.68          176.64          185.00
    141.00          159.82          167.68          177.00          186.00
    141.67          160.00          168.00          178.16          186.02
    143.00          160.03          169.00          178.40          187.89
    143.92          160.93          169.30          179.60          189.20
    144.00          161.40          169.60          179.70          190.61
    148.00          162.16          169.70          179.98          194.70
    149.34          163.78          170.60          180.55          203.85
    151.87          164.67          170.62          180.74          206.60
    153.20          165.06          172.70          180.91          209.60
    153.53          165.10          172.71          182.07          226.66
    155.80          165.99          172.92          182.29          274.80 ●
    155.87          166.55          172.92          183.00
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INTER-LABORATORY STUDY      478

POLLUTANT - SO2                          UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  1

N                 106          RANGE          241.96          C.I.(UPPER)  25.05
TRUE-VALUE      21.70          VARIANCE       508.80          C.I.(LOWE  R)  16.46
MEAN            20.75          STD. DEV.       22.56          SKEWNESS       9.08
MEDIAN          19.53          COEF. VAR.     108.69          ACCURACY     -10.00

DATA IN ASCENDING ORDER

          1.70            13.75             18.37             20.33             22.22
          1.80 ●          14.00 ●           18.50             20.35             22.50
          2.37            14.00             18.65             20.50             22.50
          4.47            14.90             19.00             20.51             23.15
          5.24            14.93             19.00             20.58             23.30
          8.00 ●          15.00             19.06             20.60             23.33
          8.87 ●          15.00             19.20             20.67             23.56
          9.26 ●          15.15             19.20             20.96             25.00
          9.66            15.29             19.23             20.96             25.08
         10.00            15.39             19.30             20.96             26.04
         10.48            15.72             19.50             20.96             26.20
         10.48            15.72             19.50             20.96             26.20
         11.00            15.72             19.56             21.20             26.80
         11.56            16.18             19.66             21.33             28.00
         11.83            16.40             19.70             21.45             30.00
         12.60            16.67             19.70             21.52             30.00 ●
         12.83            17.00             19.80             21.58             31.41
         13.10            17.55             20.00             21.61             33.30
         13.10            17.83             20.02             21.66             34.50
         13.10            18.00             20.07             21.67             65.50 ●
         13.10            18.16             20.15             21.70            165.06 ●
         13.69            18.18             20.26             22.00            243.66
         13.70            18.34             20.29             22.20
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INTER-LABORATORY STUDY      478

POLLUTANT - SO2                       UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  2

N                 112       RANGE            57.90          C.I.(UPPER)  64.29
TRUE-VALUE      64.40       VARIANCE         80.96          C.I.(LOWE  R)  60.95
MEAN            62.62       STD. DEV.         9.00          SKEWNESS      -1.41
MEDIAN          64.16       COEF. VAR.       14.37          ACCURACY       -.37

DATA IN ASCENDING ORDER

       1.29 ●         55.50          61.34          64.99          69.00
       5.00 ●         56.40          61.63          65.00          69.30
       7.00 ●         57.40          61.70          65.00          69.30
      10.70 ●         57.50          62.03          65.00          69.44
      17.36 ●         57.64          62.29          65.00          70.00
      25.43           57.64          62.43          65.50          70.00
      27.40 ●         57.64          62.50          65.50          70.20
      28.33           57.64          62.88          65.50          70.70
      32.15●          57.70          62.90          65.50          70.80
      35.10           59.50          63.33          66.22          71.00
      35.40●          59.55          63.36          66.43          71.88
      39.30           59.66          63.40          66.53          72.92
      44.77           59.90          64.00          66.67          73.36
      45.81           60.14          64.10          66.67          74.40
      47.00●          60.24          64.10          66.83          75.00
      47.77           60.26          64.22          67.00          75.20
      48.03           60.26          64.37          68.00          75.20
      49.50           60.26          64.50          68.12          75.92
      52.40           60.26          64.57          68.12          76.80
      53.00           60.88          64.60          68.12          78.74
      53.70           61.00          64.65          68.12          83.33
      54.50           61.00          64.69          68.60         132.70 ●
      55.00           61.02          64.80          68.69         230.56 ●
      55.02           61.10          64.93          68.77         579.02 ●
      55.02           61.30          64.94          68.80
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INTER-LABORATORY STUDY      478

POLLUTANT - SO2                    UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  3

N                111        RANGE          73.00        C.I.(UPPER)  65.98
TRUE-VALUE     64.70        VARIANCE      117.00        C.I.(LOWE  R)  61.95
MEAN           63.96        STD. DEV.      10.82        SKEWNESS     -1.22
MEDIAN         65.00        COEF. VAR.     16.91        ACCURACY       .46

DATA IN ASCENDING ORDER

         1.29 ●        58.06          63.00          65.52          70.83
         5.30 ●        58.42          63.20          65.77          71.00
        17.36 ●        59.00          63.36          65.88          71.70
        18.70 ●        59.50          63.70          66.05          72.00
        20.33          59.70          64.00          66.32          72.50
        20.96          60.00          64.10          66.33          73.12
        27.64 ●        60.15          64.10          66.43          73.20
        27.70          60.24          64.22          66.67          73.36
        35.10          60.26          64.57          66.89          73.36
        37.60 ●        60.26          64.58          67.40          75.20
        40.73 ●        60.50          64.75          67.43          76.36
        45.81          61.00          64.99          67.58          76.80
        47.16          61.57          64.99          68.00          77.70
        48.03          61.67          65.00          68.12          78.54
        48.84          61.88          65.00          68.12          78.60
        48.92          61.90          65.11          68.52          78.62
        49.00 ●        62.18          65.15          68.76          91.00
        52.40          62.20          65.33          69.00          91.66
        53.20          62.29          65.50          69.30          93.33
        54.90          62.30          65.50          69.44         225.32 ●
        55.02          62.30          65.50          70.00         710.02 ●
        55.02          62.80          65.50          70.40         796.70 ●
        57.50          62.88          65.50          70.58
        57.64          62.90          65.50          70.70
        58.00          63.00          65.50          70.74
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INTER-LABORATORY STUDY      478

POLLUTANT - SO2
                              UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  4

N                 111     RANGE          146.00       C.I.(UPPER) 123.99
TRUE-VALUE     126.20     VARIANCE       277.60       C.I.(LOWE  R) 117.79
MEAN           120.89     STD. DEV.       16.66       SKEWNESS          .06
MEDIAN         121.60     COEF. VAR.      13.78       ACCURACY        -3.65

DATA IN ASCENDING ORDER

       3.17 ●      111.33       119.00       123.14       129.42
      10.90 ●      112.50       119.02       123.14       129.49
      52.03 ●      112.66       119.09       123.14       129.60
      54.00        112.67       119.64       123.14       129.83
      62.00 ●      112.82       119.98       123.31       129.98
      70.20        113.50       120.06       123.80       130.21
      71.51        114.13       120.20       124.00       130.66
      75.30 ●      115.28       120.50       124.00       130.70
      81.22        116.00       120.52       124.10       130.76
      82.50        116.67       120.52       124.96       133.20
      87.00 ●      116.84       120.52       125.00       133.60
      96.00 ●      116.85       120.83       125.00       136.00
      98.38 ●      117.20       120.92       125.76       138.86
      99.00        117.59       121.00       125.76       139.64
      99.84        117.80       121.60       125.76       141.48
     100.75 ●      117.90       121.71       125.87       145.92
     104.80        117.90       121.76       126.80       149.22
     105.00        117.90       121.84       126.80       165.00
     106.60        118.00       122.07       127.60       165.06
     106.70        118.00       122.09       128.30       200.00
     107.20        118.40       122.30       128.38       343.22 ●
     107.42        118.64       122.35       128.46      1000.00 ●
     107.97        118.75       122.67       128.69
     109.41        118.80       123.02       128.97
     110.00        119.00       123.14       129.16
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INTER-LABORATORY STUDY      478

POLLUTANT - SO2                     UNITS - MICROGRAMS PER CUBIC METER

SAMPLE NUMBER -  5

N                 111        RANGE          271.33        C.I.(UPPER) 197.95
TRUE-VALUE   204.00        VARIANCE      1518.10        C.I.(LOWE  R) 183.45
MEAN         190.70        STD. DEV.       38.96        SKEWNESS       -1.89
MEDIAN       197.02        COEF. VAR.      20.43        ACCURACY       -3.42

DATA IN ASCENDING ORDER

      5.19 ●        170.50        193.40        200.30        209.60
     11.57 ●        173.33        193.66        200.39        211.98
     16.10 ●        177.13        193.80        200.49        215.40
     22.00          180.78        194.00        200.49        217.00
     28.25          181.40        194.60        200.75        217.01
     33.25 ●        183.00        195.00        201.00        217.10
     61.66          183.33        195.40        201.74        217.46
     81.30          183.52        195.62        201.74        217.46
     98.00          183.68        196.50        201.74        219.74
    110.59          184.36        196.50        201.74        223.47
    113.50          184.40        196.50        202.90        225.32
    115.26          185.60        196.50        203.00        226.18
    130.76 ●        186.02        197.00        203.33        227.94
    136.00 ●        188.58        197.02        203.94        229.00
    140.40          188.64        197.02        204.36        229.16
    153.00 ●        188.83        197.50        204.40        236.90
    154.58          189.75        197.56        205.21        249.87
    155.10          190.00        198.00        205.60        256.56
    157.00 ●        190.20        198.63        206.00        270.00
    157.20          190.65        198.72        207.47        293.33
    158.33          191.20        199.00        208.00        615.70 ●
    162.40 ●        191.26        199.12        208.30       1000.00 ●
    163.59          192.22        199.80        208.60
    165.06          193.29        200.00        209.32
    166.10          193.32        200.00        209.60
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